# City of High Point

# Storm Drainage System

# Design Manual

Effective Date:
February 1, 1994

City of High Point
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## PURPOSE

The purpose of this manual is to establish a uniform procedure for the design and analysis of storm sewer systems and their components in the City of High Point.

## INTRODUCTION

The Central Engineering Department of the City of High Point is presenting this manual to simplify and standardize the design, review, and approval of storm drainage features. These procedures will be used in the review process to determine adequacy. Engineers are not required to use the procedures presented in this manual.

The charts, tables, data, and procedures in this manual are recommended for the design of storm drainage features in the City of High Point. Engineers are encouraged to use the information as minimum requirements.

Typical data sheets are included in this manual to facilitate the review and inspection process. Required information includes: drainage basin delineation map with existing topography; drainage basin size; rainfall loss value; precipitation value; pipe, culvert or ditch geometry, slope, inverts, and roughness coefficients; plan view of improvements; and profile view for drainage systems in streets and easements.

Additional information will be required on a case-by-case basis for special materials, nonstandard structure details, manufacturer's specifications, profile view when conflicts are evident, etc.

## RATIONAL METHOD

Method for estimating rainfall runoff in drainage areas under 200 acres:

The Rational Method is the simplest method to determine the peak discharge for a small drainage basin and is limited to a maximum drainage area of 200 acres for the City of High Point's design guidelines. Engineers may elect to use an alternative method to determine peak discharges.

The Rational Formula is:

$$Q = C\ I\ A$$

$Q$ = Peak discharge in cubic feet per second
$C$ = Runoff coefficient, dimensionless
$I$ = Rainfall intensity in inches per hour
$A$ = Drainage basin in acres

(The conversion to cubic feet per second from acre-inches per hour is not necessary since the two are nearly equivalent.)

When using the Rational Method the runoff coefficient should be based on the current zoning and land usage. Minimum values are shown on page 7.

The rainfall intensity is based on two features with the Rational Method. The return period of the storm will be determined by the type of point of interest as indicated on page 7.

The rainfall intensity for a specific point of interest with a certain return period is dependent upon the time of concentration. The engineer may use any suitable method for determining the time of concentration such as the Kirpich Equation, and such methods will be reviewed by the City Engineer for adequacy.

The time of concentration for small basins within the City of High Point will be based upon the watershed run length as follows:

$$T_C = 9 + L/500$$

$T_C$ = Time of concentration in minutes
$L$ = Run length in feet

(A minimum $T_C$ of 10 minutes is typically used for small drainage basins.)

The intensity is found by using the Intensity-Duration-Frequency chart on page 9 for the specified return period and time of concentration at the point of interest.

Thus, the Rational Formula is solved for a point of interest by calculating the product of the runoff coefficient, the intensity and the drainage basin area.

# BASIN LAG-TIME METHOD

## Method for Estimating Rainfall Runoff in Drainage Areas Over 200 Acres

The Basin Lag-Time Method is a mathematical regression model developed for the Piedmont Area of North Carolina by the United States Geological Survey.

This method is acceptable in calculating rainfall runoff rates for drainage areas greater in area than 200 acres. Details of the Basin Lag-Time Method can be found in the 1972 open-file report, Effect of Urban Development on Floods in the Piedmont Province of North Carolina by Arthur L. Putnam, prepared by the U.S. Geologic Survey.

The Basin Lag-Time method is a combination of two steps leading to the calculation of peak discharge rates for the two, ten, twenty-five, and one-hundred year floods.

The two steps include: 1) The estimation of basin lag-time which is the average time interval, in hours, between the occurrence of peak rainfall and the resultant peak runoff. The equation for estimating basin lag-time is:

$$T = 0.49\ (L/\sqrt{S})^{0.50}\ I^{-0.57} \qquad \text{(page 10)}$$

T = Lag-Time in hours
L = Length of main water course in miles
S = Stream bed slope of the main water course in feet per mile
I = Ratio of the area of impervious cover to the total drainage area

Once the basin lag time has been determined, the following equations can be used to determine the appropriate peak discharge:

$$Q_2 = 221\ A^{0.87} \times T^{-0.60} \qquad \text{(page 11)}$$
$$Q_{10} = 560\ A^{0.76} \times T^{-0.48} \qquad \text{(page 12)}$$
$$Q_{25} = 790\ A^{0.71} \times T^{-0.42} \qquad \text{(page 13)}$$
$$Q_{100} = 1200\ A^{0.63} \times T^{-0.33} \qquad \text{(page 14)}$$

$Q_i$ = Peak discharge for the flood having the recurrence interval indicated by the subscript in cfs.
A = Drainage Area in square miles
T = Lag-Time in hours

Included is a set of nomographs for the 2 year, 10 year, 25 year, and 100 year recurrence interval with an example, which can be used in lieu of the above formulas.

## EXAMPLE

The following example illustrates the use of the Basin Lag-Time Nomographs.

Find the 25 year flood-peak discharge given the following Drainage Basin Information:

$A$ = 2.78 square miles
$I$ = 32% (impervious area)
$L$ = 3.22 miles from the design site to the rim of the Drainage Basin.
= 0.32 miles from the design site to a point that is 10 percent of the distance to the rim of the drainage basin.
= 2.74 miles from the design site to a point that is 85 percent of the distance to the rim of the drainage basin.

Elevation = 734 feet at the point that is 10 percent of the distance to the rim of the drainage basin.
= 870 feet at the point that is 85 percent of the distance to the rim of the drainage basin.

Compute Slope:

$$S = \frac{870 \text{ ft.} - 734 \text{ ft.}}{2.74 \text{ mi} - 0.32 \text{ mi}} = \frac{136 \text{ ft.}}{2.42} = 56.2 \text{ ft. per mile}$$

Compute Length-Slope factors:

$$L/\sqrt{S} = 3.22 / \sqrt{56.2} = 0.43$$

Determine lag-time from Page 10, plot the value of impervious cover, $I=32$, on the scale at the right; then plot the value of the length-slope factor, $L/\sqrt{S} = 0.43$, on the scale at the left. Connect these two points with a straight line and read the lag-time value, $T = 0.61$ hours, on the center scale.

Determine the 25 year flood-peak discharge from Page 13. Plot the value of lag-time, $T = 0.61$ hours, on the scale at the right; then plot the value of drainage area, $A = 2.78$ square miles, on the scale at the left. Connect these two points with a straight edge and read the 25 year flood-peak discharge value, $Q_{25} = 2000$ cubic feet per second, on the center scale.

It would be advisable that the answer be verified with the appropriate equation, until the use of the nomographs is understood.

## PROPERTY LOCATED BELOW ROAD ELEVATION

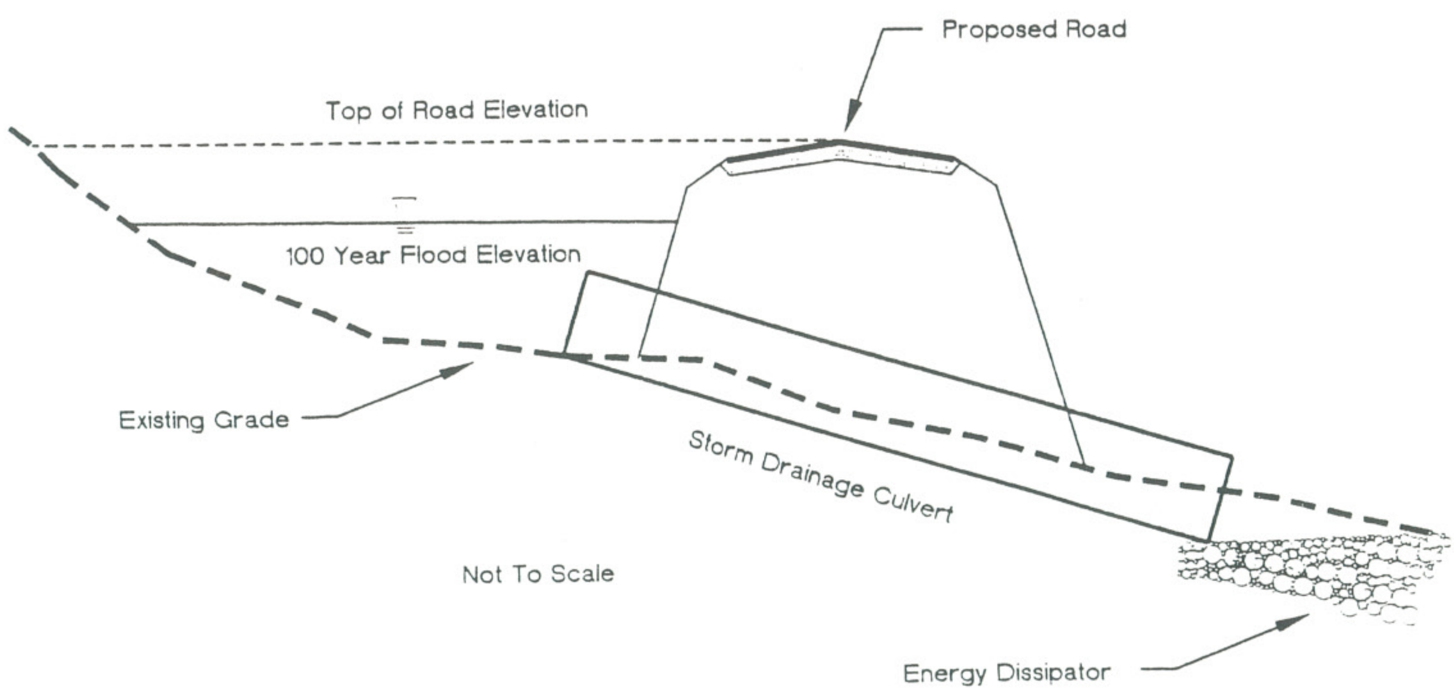
The City of High Point requires that the following criteria be used in the design and installation of storm drainage facilities that may inundate upstream properties. The following situations must meet the criteria in this section:

1. All lots located upstream of a roadway culvert that have buildable area located at an elevation lower than the roadway.

2. Any proposed storm drainage improvements that have the potential to inundate upstream properties, including improvements that increase the flow carrying potential of the storm drainage facilities.

The engineer must use a 100 year design storm for storm drainage features when upstream flooding of buildable area is a consideration. The engineer may use a lesser storm if all adversely affected area is shown as unbuildable area on a recorded plat.

The engineer must establish a 100 year base flood elevation at the culvert to aid in determining the minimum buildable elevation for property upstream of the culvert. The engineer must meet all other requirements of the City of High Point Development Ordinance as it applies to Flood Damage Prevention.



## RUNOFF COEFFICIENTS

Below are the runoff coefficients to be used in calculating stormwater runoff. All drainage areas must be assumed to be developed based on its zoning at the time of plan submittal.

| TYPE OF DEVELOPMENT (in accordance with the City of High Point Land Use Plan) | RUNOFF COEFFICIENT |
|---|---|
| Minimum Allowable Runoff Coefficient | 0.40 |
| Residential, one acre or larger lots | 0.40 |
| Residential, 1/3 acre up to 1 acre lots | 0.55 |
| Residential, less than 1/3 acre lots | 0.65 |
| Apartment, Cluster, Condominium, Light Industrial and Office Development | 0.80 |
| Paved Areas (Downtown Areas, Heavy Industrial, and Shopping Centers) | 0.95 |

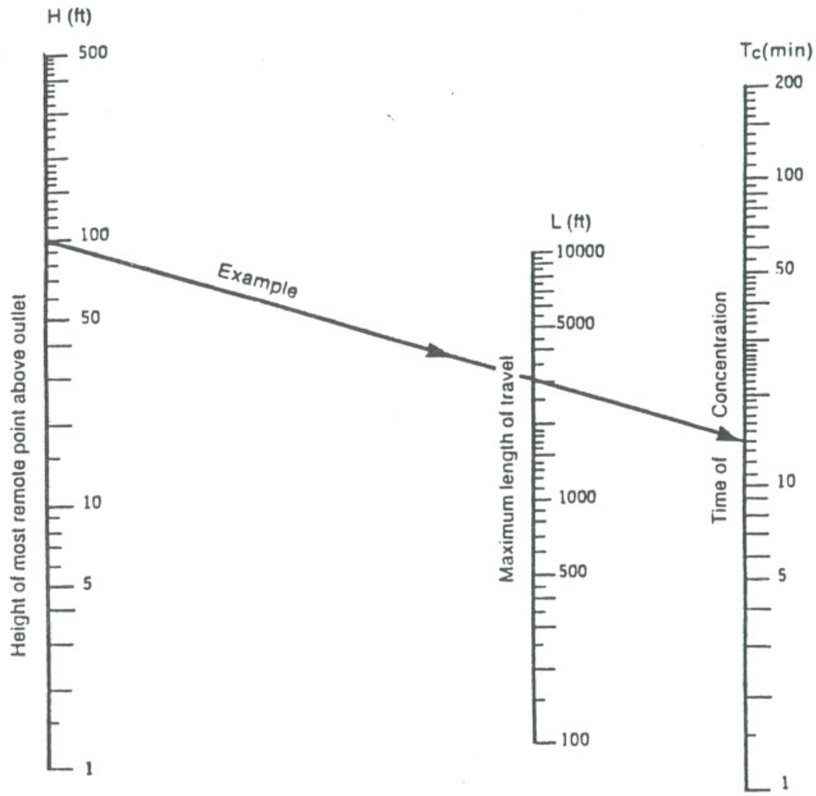
## STORM DRAINAGE DESIGN RETURN PERIOD

| | |
|---|---|
| Temporary Stabilization | 2 Years |
| Street Drainage Systems | 10 Years |
| Thoroughfare Drainage Systems | 25 Years |
| Drainage Structures for Main Drainage Channels (any identified flood zone other than Zone C on the current F.I.R.M. maps) | 100 Years |

Note: All permanent structures must be elevated and setback from main drainage channels and/or flood plains in accordance with the City of High Point Development Ordinance and Federal Emergency Management Agency regulations.

# TIME OF CONCENTRATION FOR SMALL DRAINAGE BASINS






Note:

Use this nomograph for natural basins with well-defined channels, for overland flow on bare earth and for mowed-grass roadside culverts (based on the Kirpich Equation).

For overland flow on grassed surfaces, multiply Tc by 2.

For overland flow on concrete or asphalt surfaces, multiply Tc by 0.4.

For concrete channels, multiply Tc by 0.2.

Example using the Kirpich Equation nomograph:

Assume flow is on concrete surfaces.

H = 100 feet

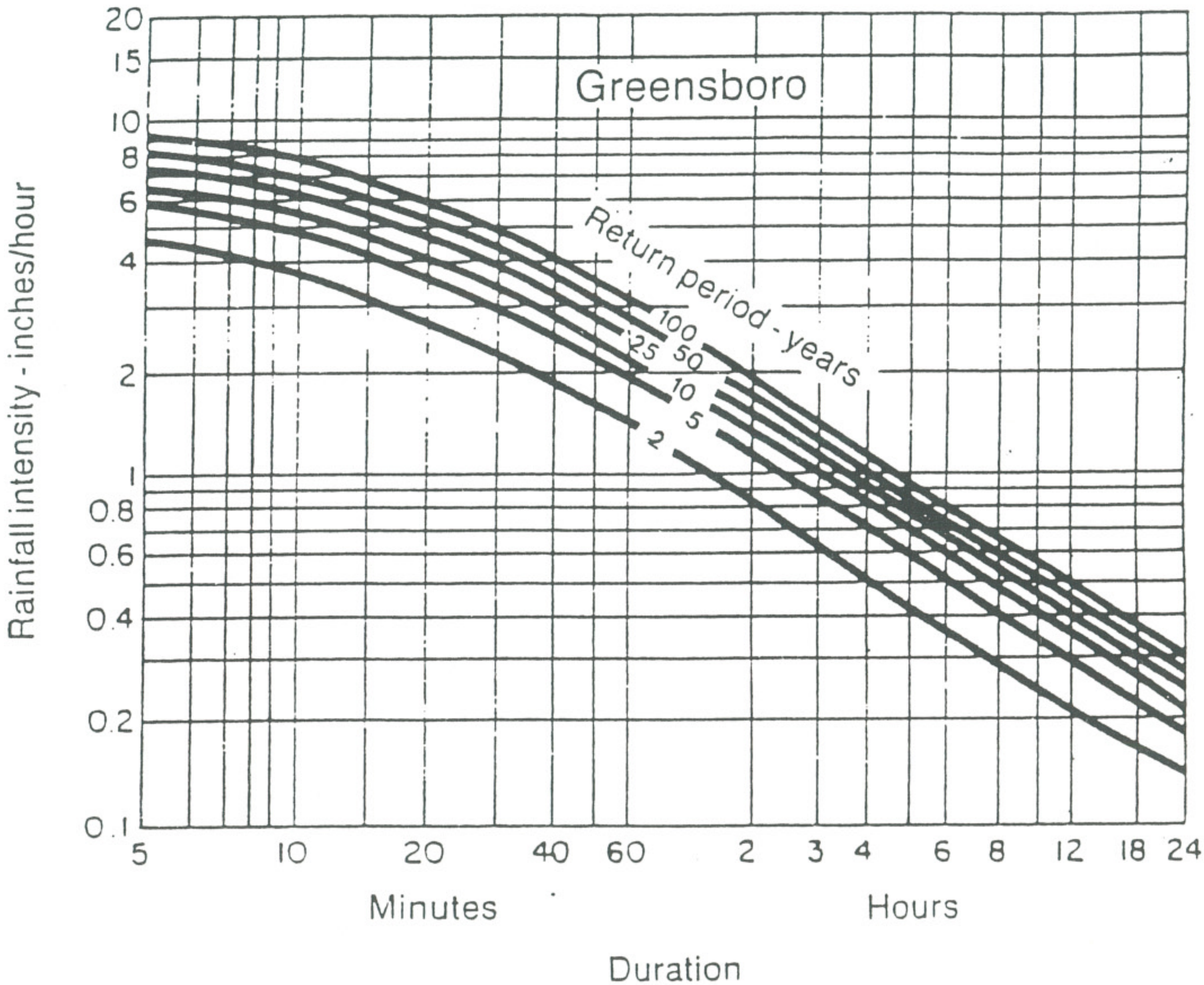
L = 3,000 feet

Tc = 14 minutes (unadjusted)

Tc = 14 min. * 0.4 = 5.6 minutes

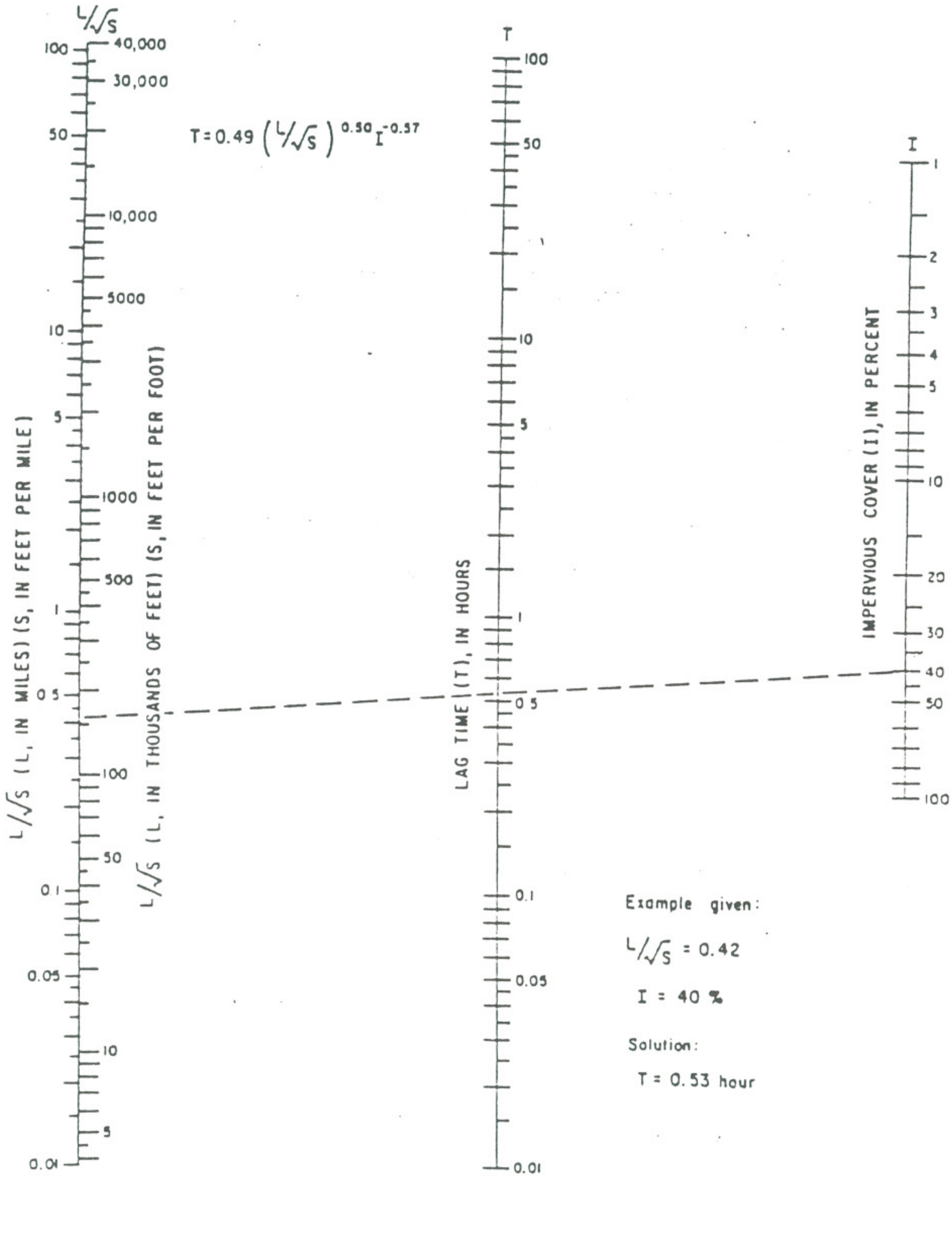
source: North Carolina Erosion and Sedimentation Control Planning and Design Manual (nomograph, adjustment factors)

# INTENSITY-DURATION-FREQUENCY CURVES



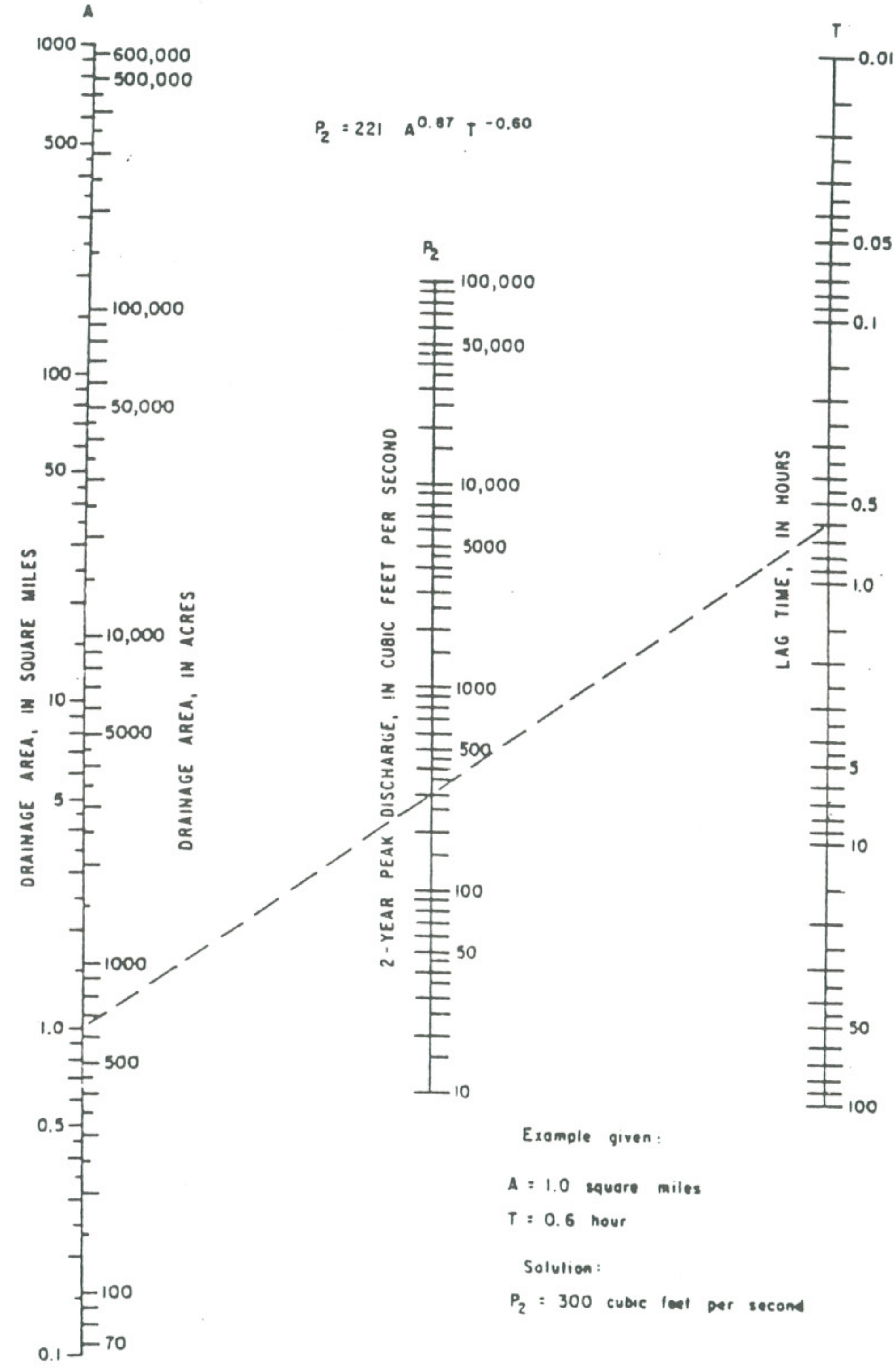

source: North Carolina State Highway Commission, January 1973

# BASIN LAG TIME METHOD: LAG TIME



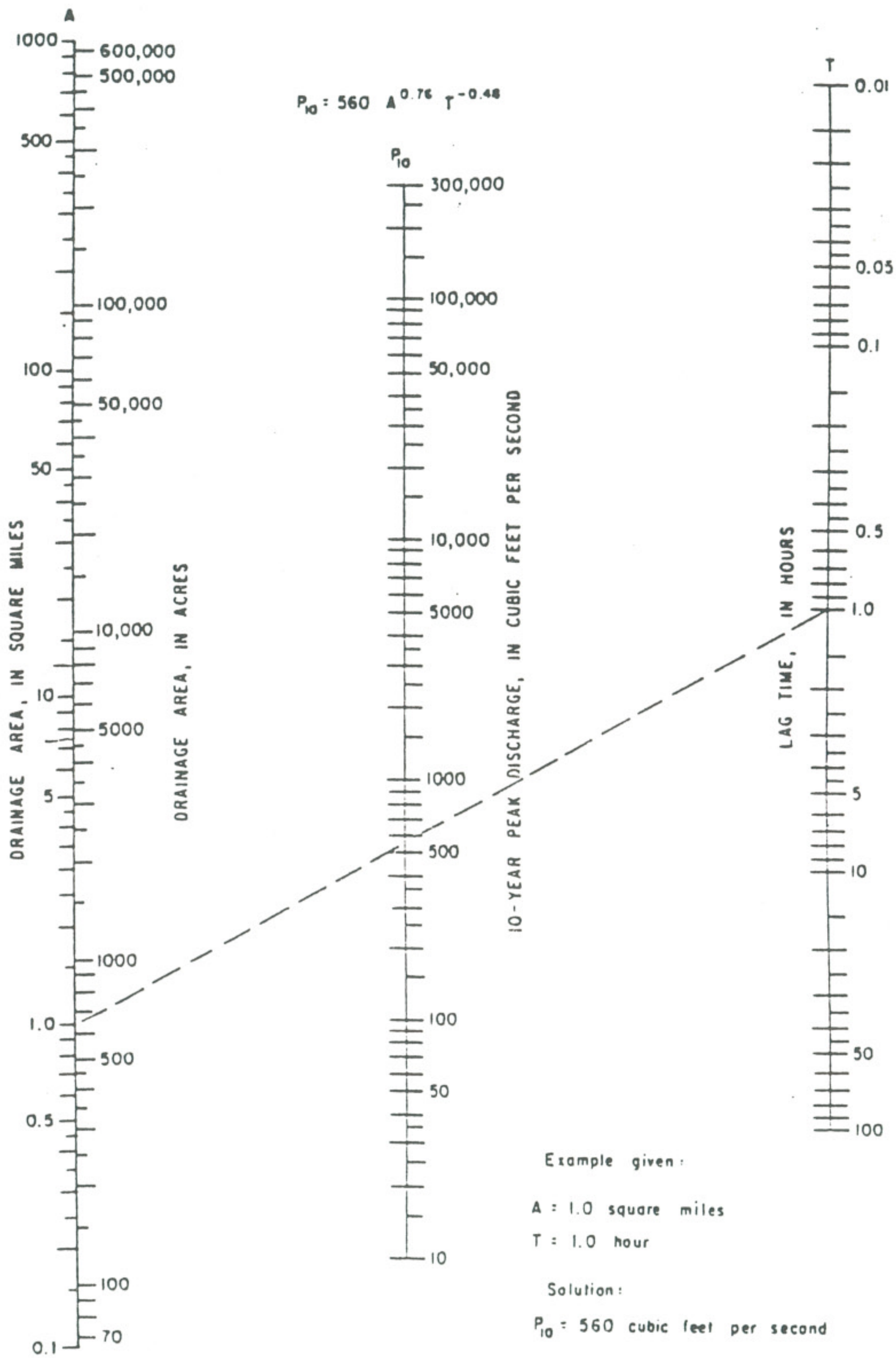

source: USGS <u>Effect of Urban Development on Floods in the Piedmont Province of North Carolina</u>, 1972

# BASIN LAG TIME METHOD: 2-YEAR FLOOD PEAK



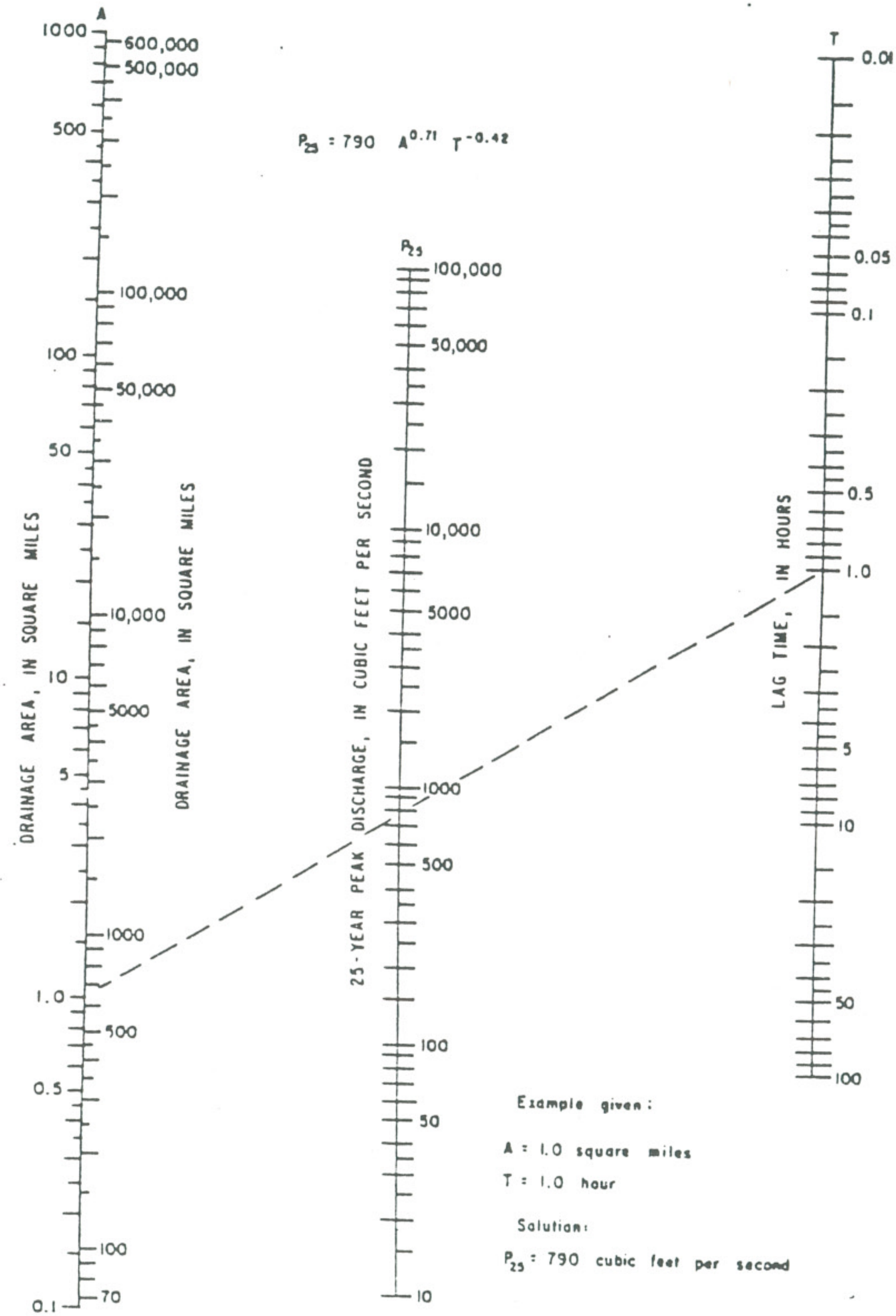

source: USGS <u>Effect of Urban Development on Floods in the Piedmont Province of North Carolina</u>, 1972

# BASIN LAG TIME METHOD: 10-YEAR FLOOD PEAK



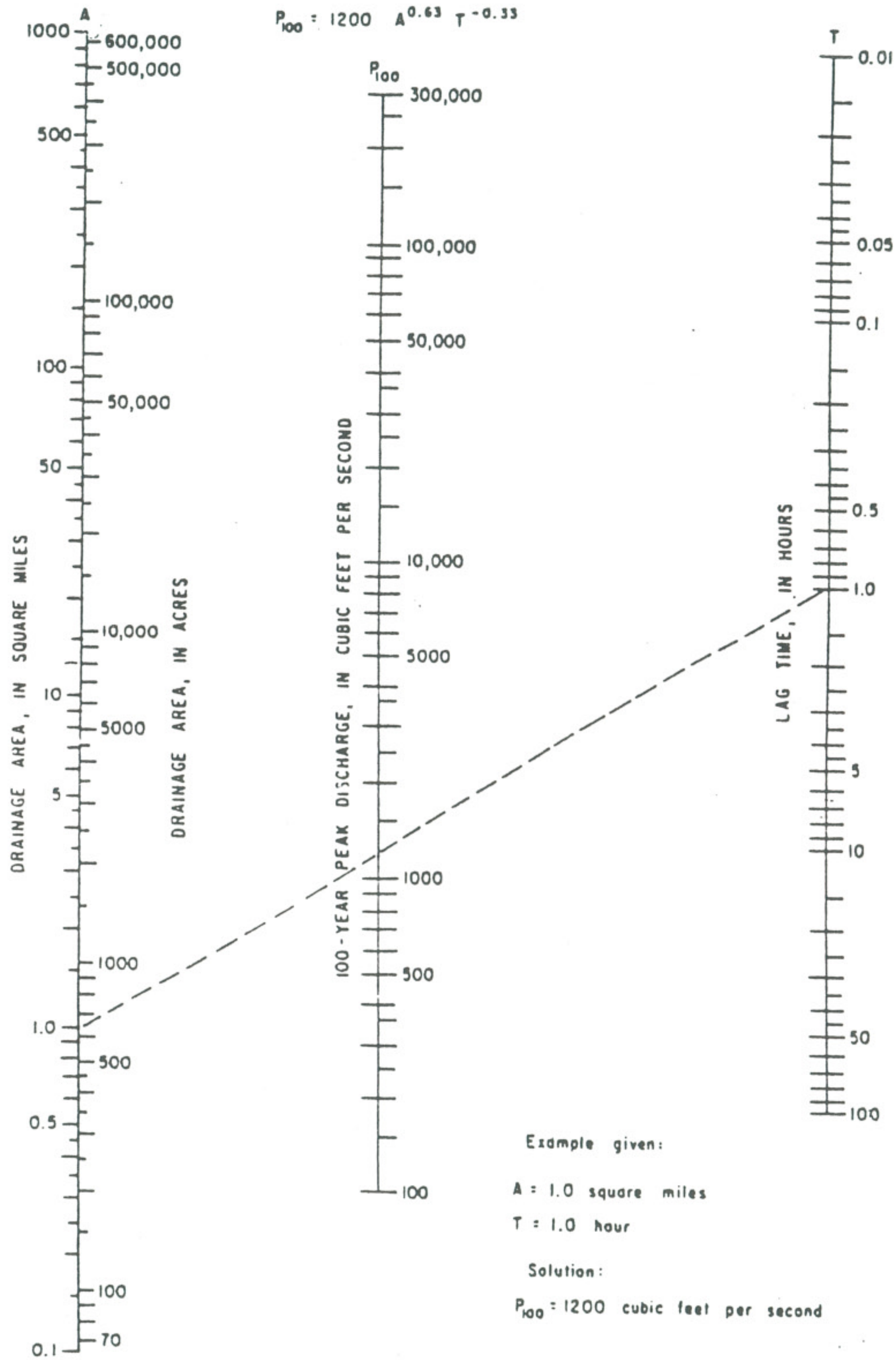

source: USGS Effect of Urban Development on Floods in the Piedmont Province of North Carolina, 1972

# BASIN LAG TIME METHOD: 25-YEAR FLOOD PEAK




source: USGS Effect of Urban Development on Floods in the Piedmont Province of North Carolina, 1972

# BASIN LAG TIME METHOD: 100-YEAR FLOOD PEAK




source: USGS <u>Effect of Urban Development on Floods in the Piedmont Province of North Carolina</u>, 1972

## GUTTER CAPACITY

The flow of water in a gutter section shall be limited by the allowable spread from the face of curb. The allowable spread will be determined by the following factors:

1. The gutter flow depth is limited by the curb height.

2. The allowable spread may in no case be greater than one half lane of travel.

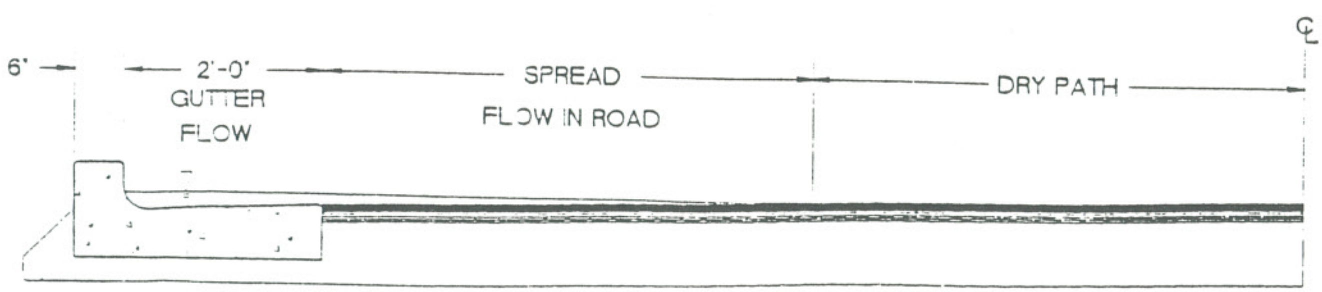
3. The allowable spread must consider the road superelevation.

The required engineering calculations for flow and capacity at inlets will be used to determine the adequacy of the gutter section.

The Gutter Capacity chart on Page 16 may be used to determine gutter capacity for roads with typical gutter sections and normal crown. Curves indicate flow capacity for allowable spreads as labelled.

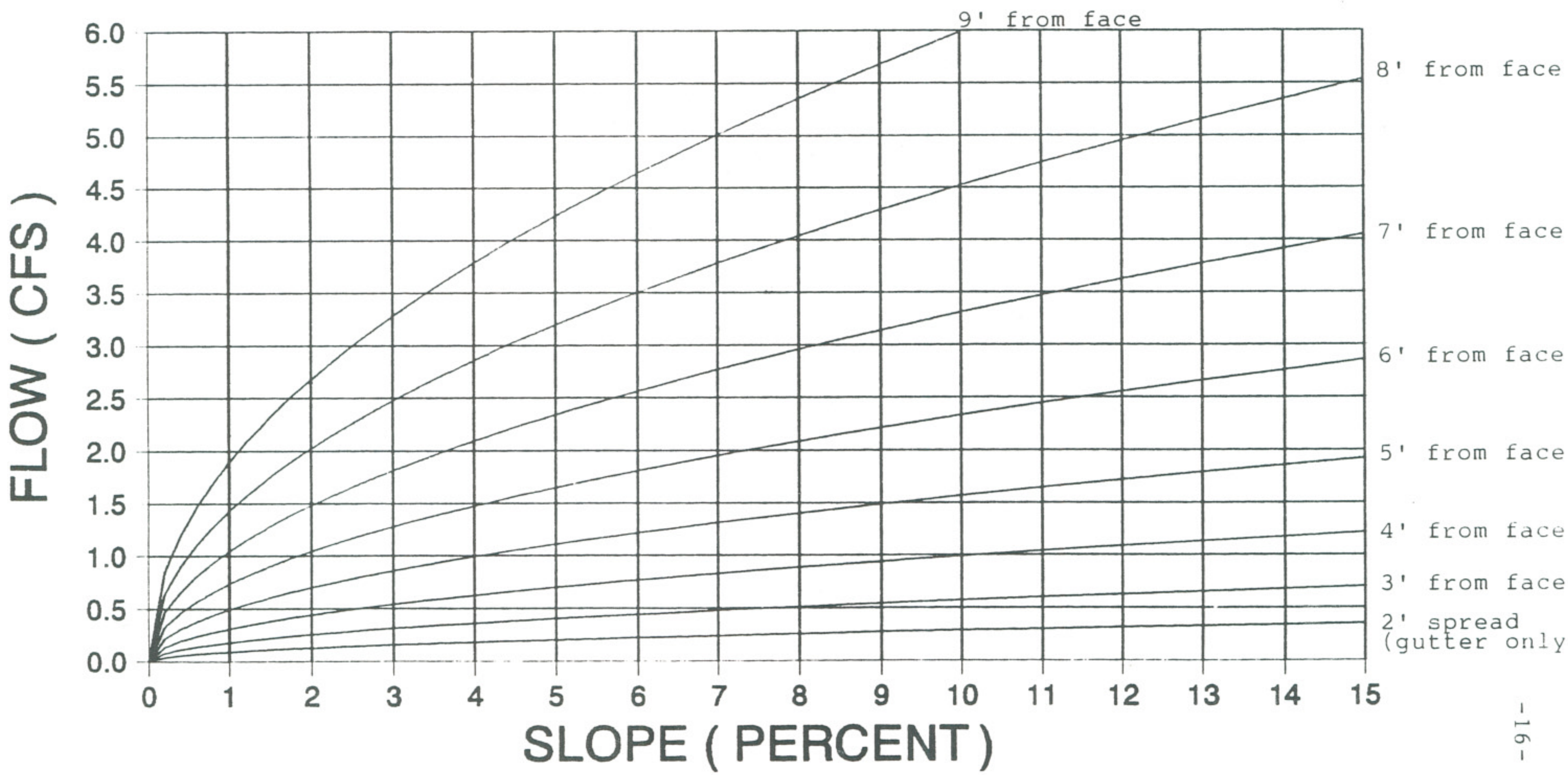
The chart is based on Mannings Equation applied to the gutter section and the roadway section based on a fixed depth (since the allowable spread sets the depth). The flow in the gutter is combined with the flow in the roadway for the curves on the chart. Similar curves could be easily developed for superelevated roads by using a spreadsheet. The City Engineer may require calculations for gutter flow when superelevated roads are proposed on a case by case basis.

In an effort to simplify the submittal and review time, no additional information will be required in most cases. In specific conditions where gutter flow controls, the gutter flow will be reviewed as the intercepted flow plus any previous bypass flow. Consideration will be given to changes in grade and concentrated flows that may enter the gutter.



# GUTTER CAPACITY

BASED ON THE TYPICAL GUTTER SECTION
AND NORMAL CROWN, N = 0.016



## YARD INLET CAPACITY

The capacity for yard inlets shall be based on the limiting depth at the structure. The limiting depth should consider the following factors:

1. The required depth and resulting elevation of the water shall protect life, health and property.

2. The elevation of the water at the design depth may not top curb elevations.

The required engineering calculations for flow and capacity at inlets will be used to determine the adequacy of the yard inlets. The construction details or plans must indicate the actual number of open sides and weir length and opening height for yard inlets.

The Yard Inlet Capacity chart on Page 18 may be used to determine capacity for yard inlets with one typical opening size of 2'-8" wide by 6" high with a weir coefficient of 3.00 and an orifice coefficient of 0.60. The chart is based on the limiting flow calculated by the weir or orifice equation for various depths. The chart assumes a smooth transition from weir to orifice flow. The flow to be intercepted at a yard inlet should be adjusted for the number of open sides or actual opening width that will be used.

Weir Formula:

$$Q_w = C_w * l * h^{3/2}$$

$Q_w$ = Weir flow in cfs
$C_w$ = Weir coeff.
$l$ = Weir length in feet
$h$ = Flow Depth in feet

Orifice Formula:

$$Q_o = C_d * A * ( 2 * g * h )^{1/2}$$

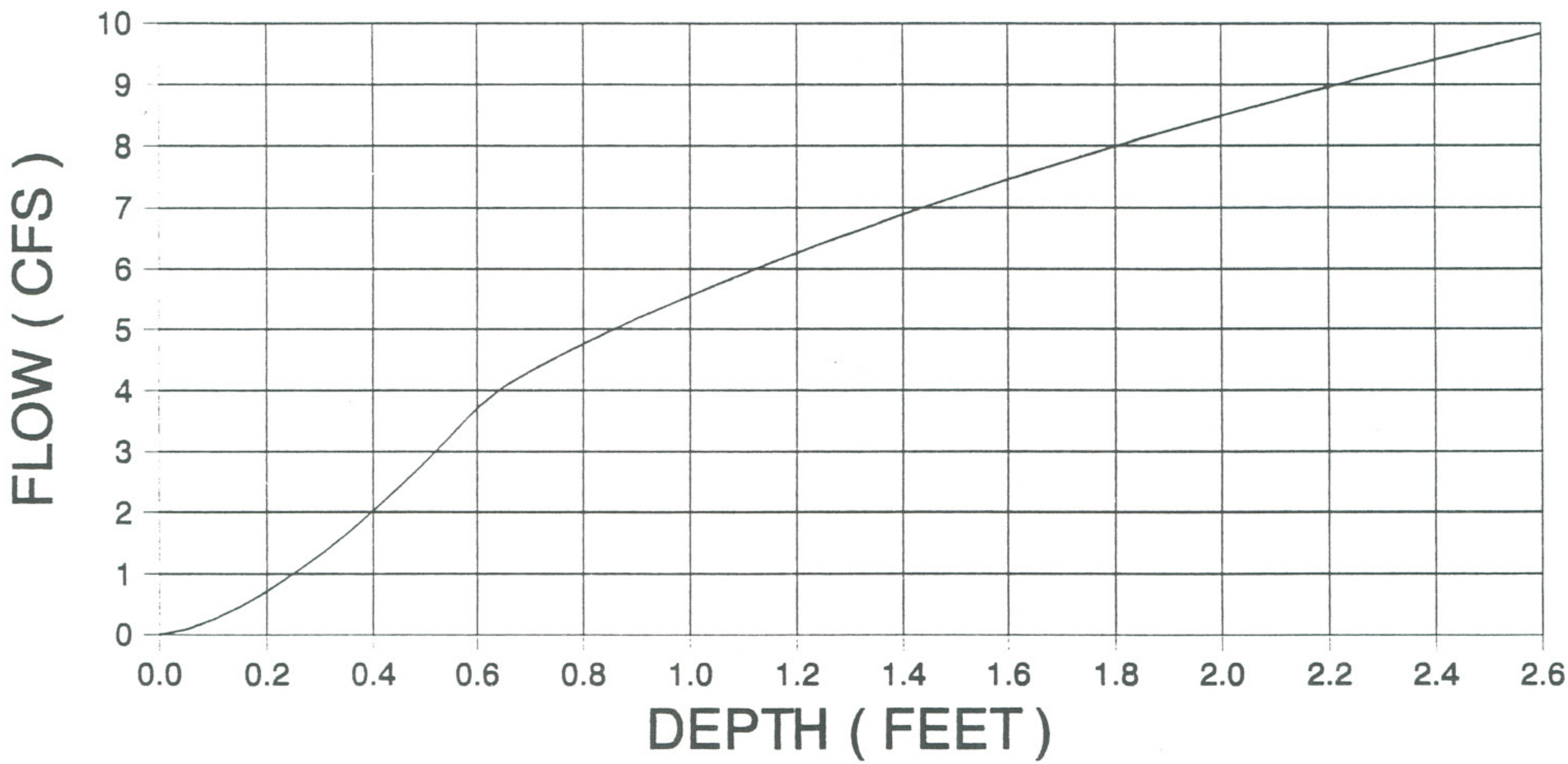
$Q_o$ = Orifice flow in cfs
$C_d$ = Orifice coeff.
$A$ = Opening area in $feet^2$
$g$ = 32.2 $ft./sec^2$
$h$ = Head at mid-opening height in ft

In an effort to simplify the submittal and review time, no additional information will be required in most cases. In specific conditions where the design depth seems unreasonable, the City Engineer may require certification (with supporting technical data) that the design storm will not endanger life, health or property.

$Q = C L h^{1.5}$
$h = \sqrt[1.5]{\frac{Q}{cL}}$

# YARD INLET CAPACITY

BASED ON ONE 2'-8" x 6" OPENING
Cw = 3.00 Cd = 0.60




* CHART BASED ON ONE OPEN SIDE ONLY. ADJUST CAPACITY FOR THE TOTAL OPENING LENGTH.

## GRATED INLETS

The City of High Point requires that the following information be provided when grates are proposed for inlets. The engineer shall provide details that indicate the geometry of the overall grate and frame, the typical opening dimensions and the design traffic or load condition.

The grate shall be selected with considerations that include, but are not limiited to, the following:

- The grate shall be sized for the flow to be intercepted at a reasonable depth.
- The openings should be sized to minimize maintenance.
- Geometry must allow for easy access to the structure.
- The grate should be suitable for all likely traffic loads.
- The openings shall be suitable for likely pedestrian and bicycle traffic.

The flow calculations should be based on independent research of flow performance or the orifice formula as indicated below:

$$Q_o = Cd * A * ( 2 * g * H )^{0.5}$$

$Q_o$ = Orifice flow in cfs
Cd = Orifice coefficient, usually near 0.60
A = Total opening area in square feet
g = Acceleration due to gravity, 32.2 ft/sec$^2$
H = Mean depth of water above the opening in feet

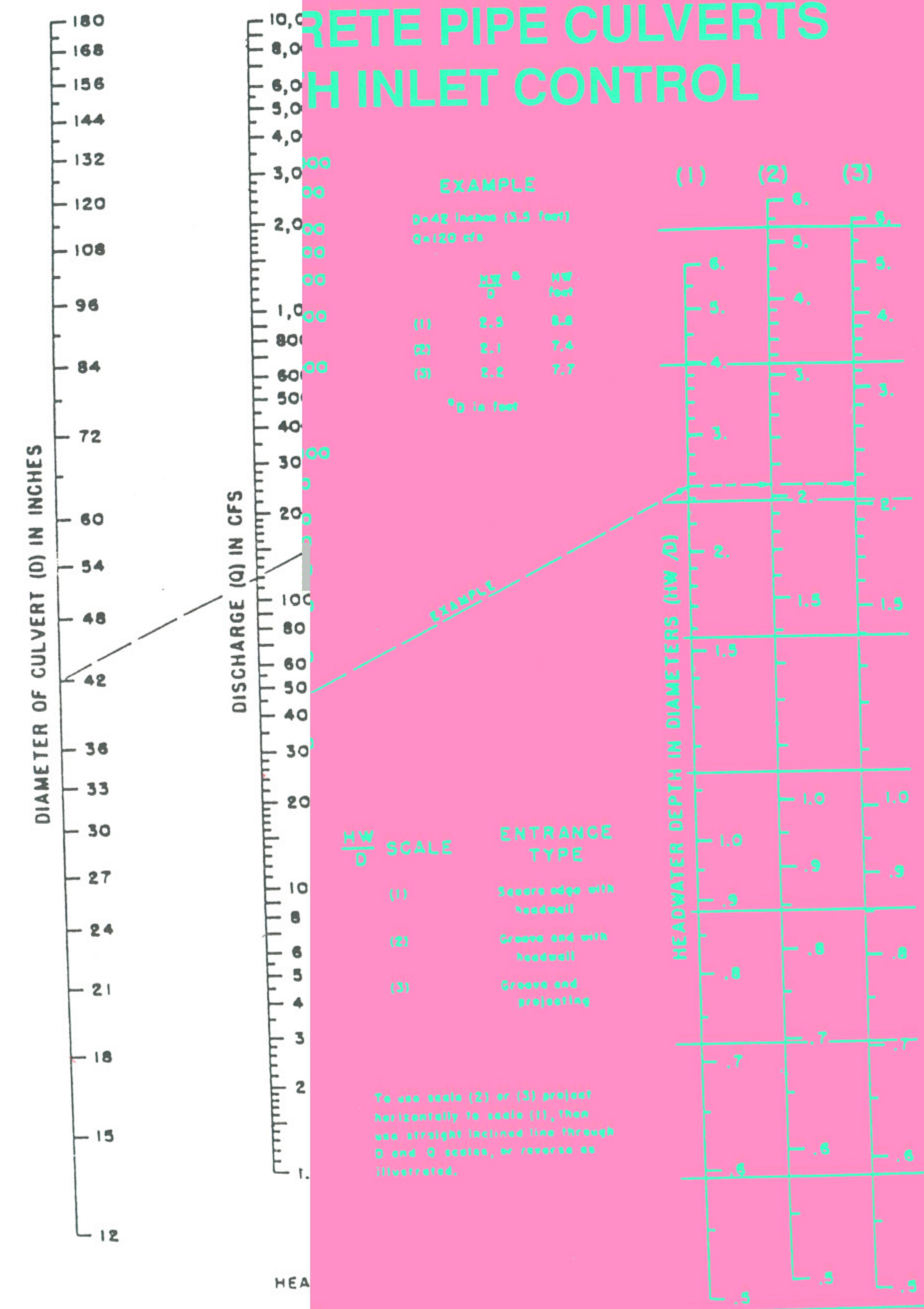
The engineering data is required to be submitted with the plans. Construction data is required on the plans to indicate the location of grated inlets and provide the necessary construction details.

DWATER SCALES 2&3
REVISED MAY 1964

CONCRETE PIPE CULVERTS
WITH INLET CONTROL



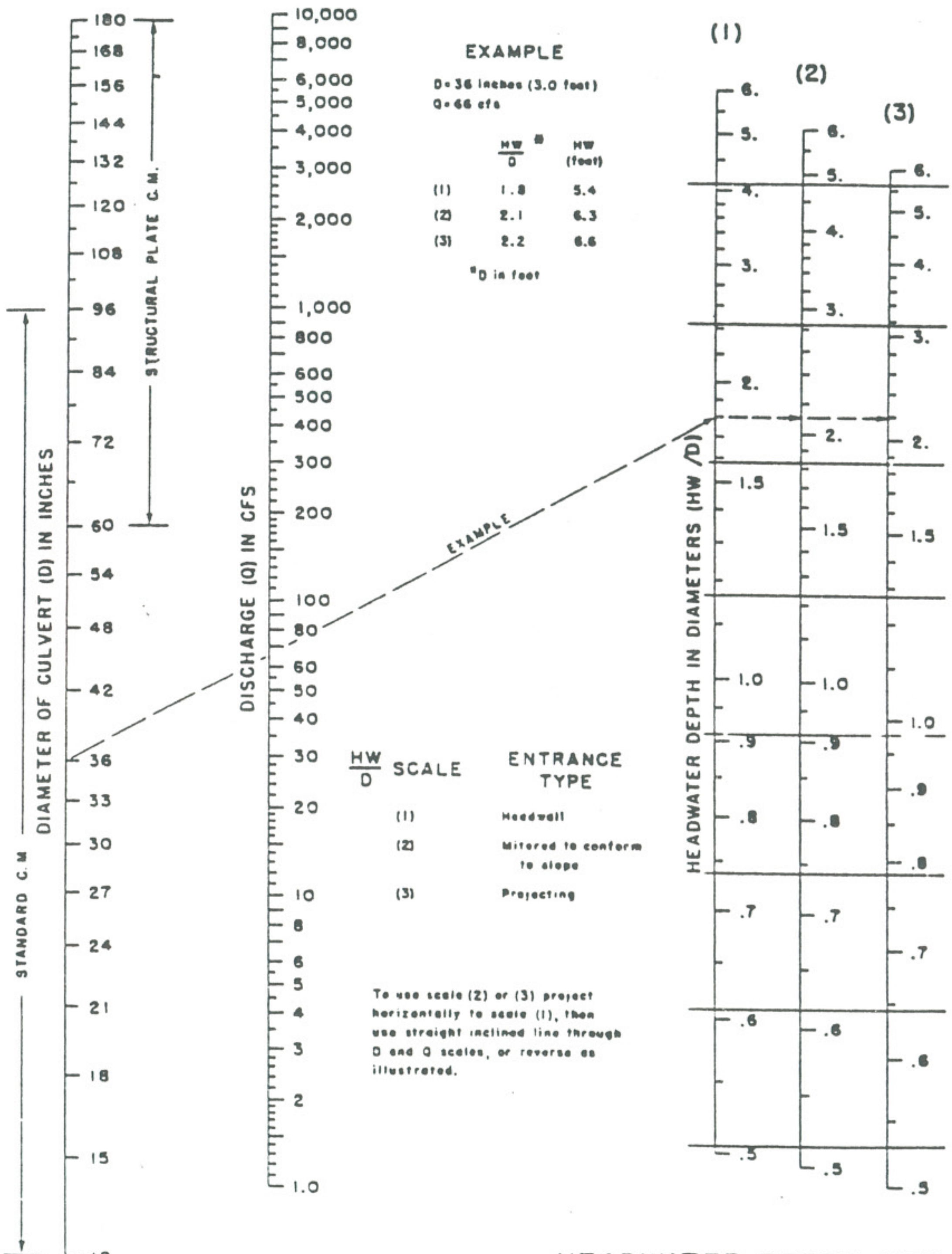
# HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL




BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR

# HEADWATER DEPTH FOR CORRUGATED METAL PIPE CULVERTS WITH INLET CONTROL




HEADWATER DEPTH FOR
C. M. PIPE CULVERTS
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

## ENERGY DISSIPATORS

The City of High Point requires energy dissipators at the discharge locations of all storm drainage pipes, unless calculations are provided that indicate erosion will not occur based on the flow, slope and soil type. The engineer shall provide details that indicate the location, dimensions and mean rip-rap diameter required, as indicated below:

- Q = Design discharge in cfs
- La = The apron length in feet
- W = The downstream apron width in feet
- $d_{50}$ = The mean rip-rap diameter in inches

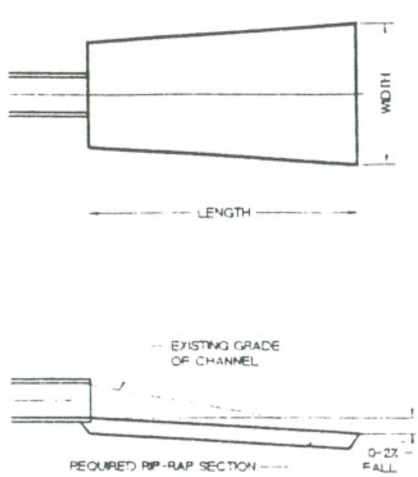
The dissipator shall be based on the Maryland Method (consistent with the North Carolina Erosion and Sediment Control Planning and Design Manual) using the charts on Pages 23 and 24. The City of High Point requires a minimum $d_{50}$ diameter of 6". The minimum placement thickness shall be: 1.5 times the maximum rip-rap diameter, which is 1.5 times the $d_{50}$ diameter; or 1.5 times the $d_{50}$ diameter when using a filter beneath the apron. Energy dissipators shall be placed at 0.0 to 2.0 % grade, but we recommend a range of 0.5 to 1.0 %. The invert elevation at the discharge point shall be based on the existing grade of the watercourse plus the fall across the apron.

The dissipator shall be selected based on the nature of the receiving watercourse:

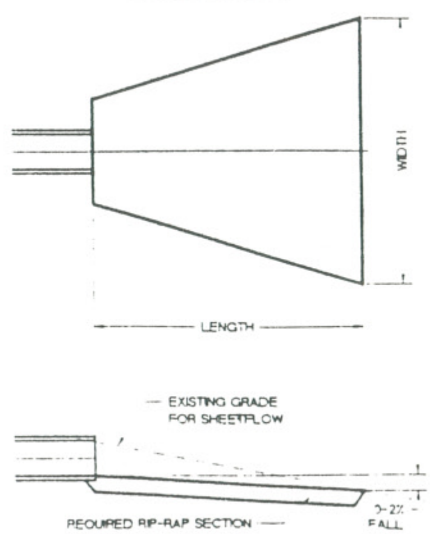
1. Pipes discharging to well defined channels shall be sized for maximum tailwater conditions. Energy dissipators in well defined channels should minimize bends and should be aligned with the receiving watercourse.

2. Pipes discharging to near sheetflow conditions shall be based on minimum tailwater conditions. Energy dissipators distributing flow over a wide area must be level across the discharge end to assimilate sheetflow.

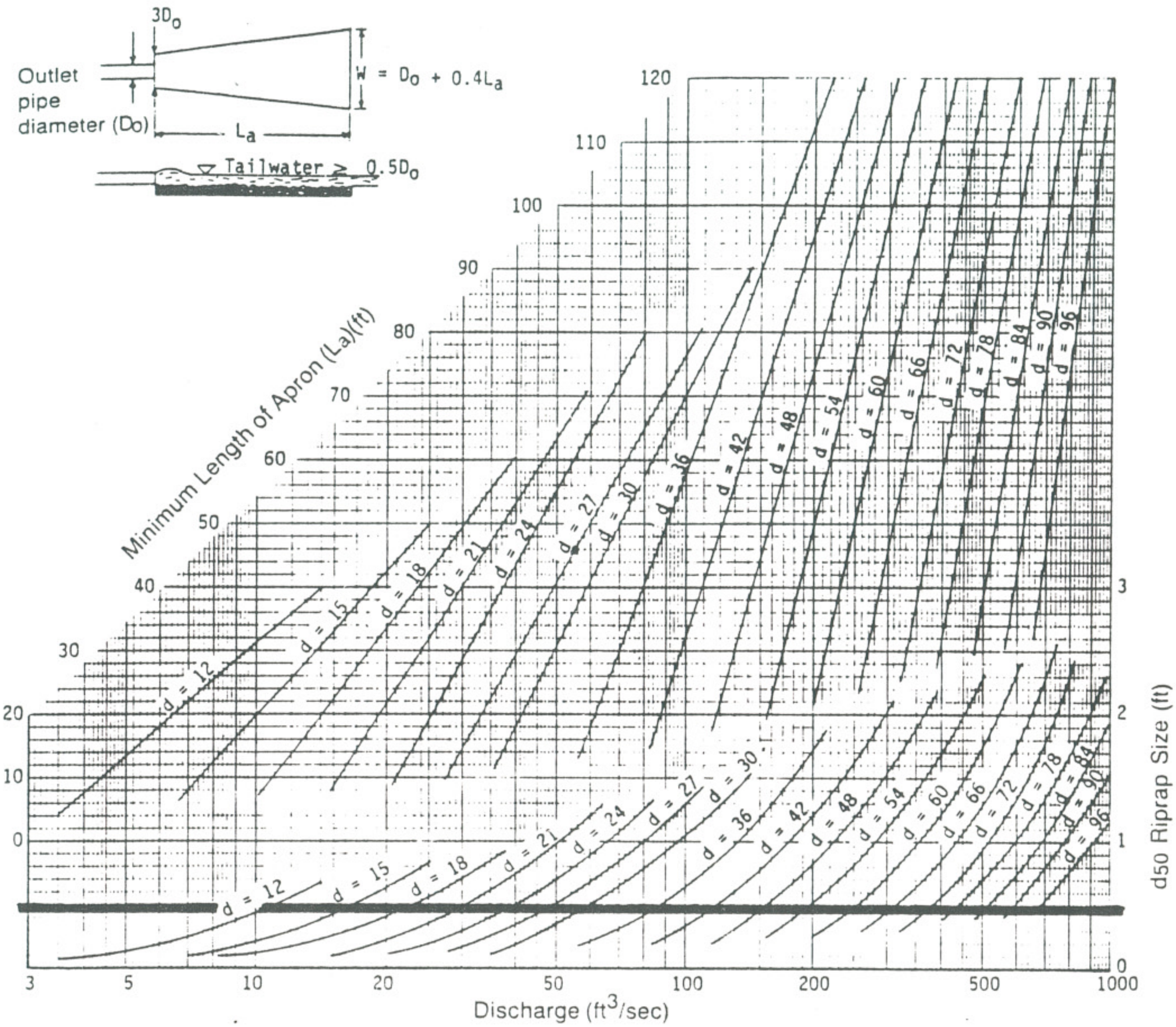
ENERGY DISSIPATOR FOR DEFINED CHANNELS




ENERGY DISSIPATOR FOR SHEETFLOW



# ENERGY DISSIPATOR TO A WELL-DEFINED CHANNEL

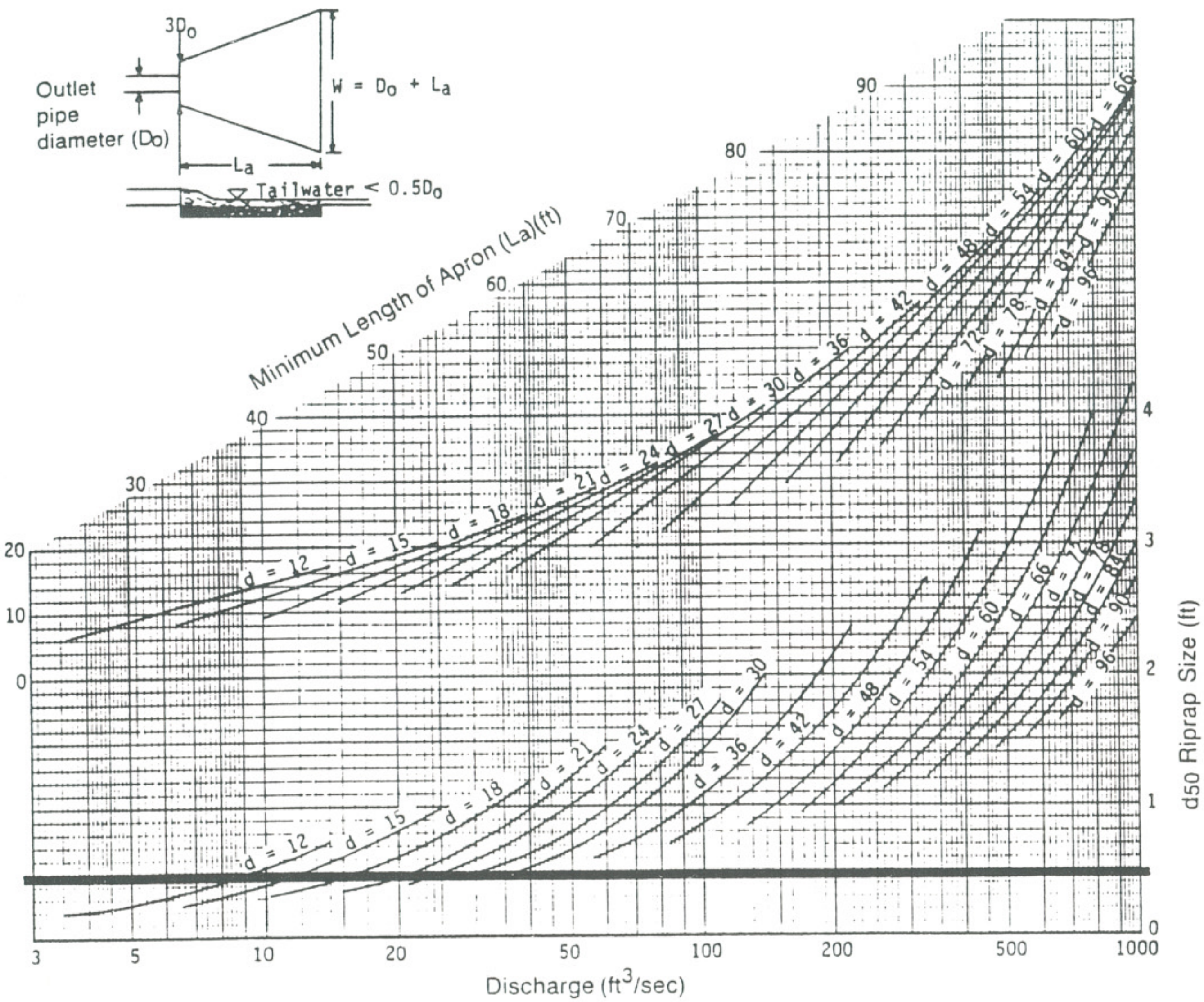



The minimum d50 rip-rap size shall be 6".

Curves may not be extrapolated. Alternate energy dissipator designs may be approved when outlet conditions are beyond the limits of this chart.

source: USDA-Soil Conservation Service-Maryland

# ENERGY DISSIPATOR TO SHEETFLOW CONDITIONS




The minimum d50 rip-rap size shall be 6".

Curves may not be extrapolated. Alternate energy dissipator designs may be approved when outlet conditions are beyond the limits of this chart.

source: USDA-Soil Conservation Service-Maryland

## STORM DRAINAGE DESIGN RECOMMENDATIONS AND REQUIREMENTS

The City of High Point requires that the following criteria be used in the design and installation of storm drainage components for all publicly maintained systems or for privately owned systems that affect publicly owned systems.

1. Storm sewer components shall have adequate capacity to carry the design storm indicated on page 7 based on the type of system required. The capacity shall be based on <u>inlet capacity, Manning's Equation</u> and <u>Bernoulli's Equation</u>. Systems based solely on Manning's Equation typically have inadequate headwater conditions or discharge into a submerged location.

2. Storm sewer pipe shall be reinforced concrete pipe class III or class IV, with a minimum diameter of 15". Smaller diameter storm sewer pipe may be used on a case by case basis with approval by the City Engineer. All storm sewer pipe joints and structures shall be installed with an approved sealing material as determined by the City Engineer.

3. Storm sewer pipe smaller than 24" in diameter shall have a minimum grade of 1.0 %. Pipe 24" in diameter or larger shall be laid at a suitable grade, adequate to provide a full flow velocity of 6 feet per second.

4. The maximum storm sewer grade allowed is 10.0 %. Pipes discharging to watercourses or natural features should be installed at moderate grades to promote vegetative stabilization.

5. The minimum grade for tailditching shall be 1.0 %.

6. Energy dissipators are required at all release points unless calculations indicate that erosion will not occur based on the flow, outlet velocity and soil condition. Headwalls or flared end sections may be required at release points as determined by the City Engineer.

7. The minimum recommended drops at structures are as follows:

    a. Change in alignment 0 - 45 degrees: 0.10 feet

    b. Change in alignment 45 or more degrees: 0.20 feet

    c. Change in pipe size: align top insides of pipes

8. At locations where a proposed pipe is to flow into a smaller diameter pipe (whether existing or proposed), the City Engineer must approve the design. Similarly, arch pipes used (due to headwater conditions or conflicts) that have a smaller dimension than an upstream pipe must be approved by the City Engineer.

9. Drainage systems shall be designed to prevent the diversion of water.

10. Site drainage shall not flow out of driveways into streets, whenever it is feasible to connect to a storm drainage system.

11. No more than one acre may drain into a street at a single concentrated point.

12. The following storm drainage information is required for approval:

a. Plan view of all inlets, manholes, junction boxes, and pipe lines with pipe sizes, lengths, slopes and inverts clearly labelled.

b. Storm drainage features adjacent to the proposed development should be shown along with ditches, swales, pipes and easements.

c. A drainage basin delineation map showing the existing contours and the limits of the drainage area, with the scale shown on the map, is required. The site plan, street plan or aerial topographic maps may be used for a detailed drainage basin delineation map. Delineation maps do not need to be reproducible.

d. Storm drainage calculations must be submitted in a format similar to the sheets shown on pages 28 through 30. The engineering data is required to be submitted with the plans, and the construction data is required on the plans to facilitate review and ease of construction.

# STORM DRAINAGE SCHEDULE GUIDELINES

Use the following abbreviations as types of structures:

| | | | |
|---|---|---|---|
| CB | - Catch Basin | MH | - Manhole |
| FES | - Flared End Section | PI | - Pipe Inlet |
| GI | - Grated Inlet | PO | - Pipe Outlet |
| HW | - Head Wall | YI | - Yard Inlet |
| JB | - Junction Box with Access | | |

* For FES, PI & PO indicate the necessary energy dissipator geometry and rip-rap designation in the "remarks" column.

* All pipe shall be reinforced concrete pipe (RCP) unless approved by the Central Engineering Department and clearly noted on the plans and in the "remarks" column.

* Bernoulli's Equation and Hydraulic Grade line calculations are optional. All other columns must be completed.

Use the following K values for minor losses in the Bernoulli Equation:

Contraction loss at pipe inlet (required): 0.25
Expansion loss at pipe outlet (required): 0.35
Changes in direction of flow:

| | |
|---|---|
| 90 degrees: 0.70 | 40 degrees: 0.38 |
| 80 degrees: 0.66 | 30 degrees: 0.28 |
| 70 degrees: 0.61 | 25 degrees: 0.22 |
| 60 degrees: 0.55 | 20 degrees: 0.16 |
| 50 degrees: 0.47 | 15 degrees: 0.10 |

source: North Carolina Division of Highways
<u>Guidelines for Drainage Studies and Hydraulic Design</u>

# Construction Storm Drainage Schedule

PROJECT ____________ FIRM ____________

LOCATION ____________ ENGINEER ____________ CHECKED ____________

ASSUMPTIONS : CB – Catch Basin HW – Headwall PI – Pipe Inlet
FES – Flared End Section JB – Junction Box PO – Pipe Outlet
GI – Grated Inlet MH – Manhole YI – Yard Inlet

| Structures | | From Structure Elevations | | To Structure Elevations | | Pipe Diameter (in) | Pipe Length (ft) | Slope (%) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| From | To | Top | Invert | Top | Invert | | | | |
| | | | | | | | | | |

# Engineering Storm Drainage Schedule

PROJECT ____________________ FIRM ____________________

LOCATION ____________________ ENGINEER ____________________ CHECKED __________

ASSUMPTIONS : INLET values are intercepted by the structure.
PIPE values are the accumulated values in the pipe.
Tc is based on ____________________ method.
________ Year design storm is being used.



| Structures | | Drainage Basins | | C | Basin Length | Tc | ____ Year | Flow | | Pipe Velocity | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Inlet (acres) | Pipe (acres) | | (feet) | (minutes) | Intensity (in/hr) | Inlet (cfs) | Pipe (cfs) | (ft/sec) | |

# Engineering Storm Drainage Schedule

PROJECT ____________ FIRM ____________

LOCATION ____________ ENGINEER ____________ CHECKED ____________

ASSUMPTIONS : Pipes are flowing full and n ____
Headwater capacity basis : ____ Charts or Cd ____

K Values :

| | | | | | |
|---|---|---|---|---|---|
| Contraction | 0.25 | 70 degrees | 0.61 | 30 degrees | 0.28 |
| Expansion | 0.35 | 60 degrees | 0.55 | 25 degrees | 0.22 |
| 90 degrees | 0.70 | 50 degrees | 0.47 | 20 degrees | 0.16 |
| 80 degrees | 0.66 | 40 degrees | 0.38 | 15 degrees | 0.10 |



| Structure | | Inlet Structure | | Headwater Depth | | n | Pipe Flow (cfs) Bernoulli's Equation | | | Hydraulic Grade Line | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Capacity (cfs) | Bypass (cfs) | Available (feet) | Required (feet) | Manning's (cfs) | Hf (ft) | Total K | Hm (ft) | Outlet | Inlet | |
| | | | | | | | | | | | | |

# STORMWATER GUIDELINES FOR WATER QUALITY AND FLOOD CONTROL

The following guidelines detail three methods accepted by the City of High Point for engineering certification of watershed protection controls. Natural infiltration is the preferred method, and should be used as the first alternative. If this is not feasible or practical, the recommended method of control is wet pond detention basins. Where local conditions prevent the use of wet detention, dry detention basins may be an acceptable alternative.

## NATURAL INFILTRATION

The following equation will be used to determine if the first half inch of runoff from an impervious surface can be retained on-site by natural infiltration.

Equation 1:

$$U = (K)(T)(I)/[(C)(d) - .5]$$

where

- U = Natural Infiltration area needed for infiltration of runoff from impervious surface, acres.
- K = .5, a constant representing the first half inch
- T = Total acres of land in the tract, or land under consideration.
- I = Impervious surface, %/100.
- C = Effective water capacity, In./In. (water/soil).
- d = Depth of soil A horizon, In. (determined from Table 2 or on-site investigation).
- .5 = First half inch of rainfall.

Effective water capacity (C) and infiltration rate (f) are functions of soil texture as presented in Table 1:

TABLE 1

| Soil Texture USDA Classes | C In./In. | f In./Hr. | Hydrologic Group |
|---|---|---|---|
| Sandy loam | .25 | 1.02 | B |
| Fine sandy loam, loam | .19 | .52 | B |
| Silt loam, sandy loam**, fine sandy loam** | .17 | .27 | C |
| Sandy clay loam | .14 | .17 | C |
| Clay loam | .14 | .09 | D |
| Clay | .08 | .02 | D |

**Sandy loam and fine sandy loam overlying slowly permeable, clayey B horizon which will perch water.

F = infiltration rate, In./Hr.
Some basic requirements for the undisturbed area are:

1. Runoff from the impervious surface (I) flows onto the undisturbed area (U) as sheet flow, using structures or diversions if necessary to accomplish sheet flow.

2. Undisturbed area (U) -
   a. is less than 10% slope
   b. has an excellent wood cover, (multiply U by 2 for grass cover)
   c. is not a floodplain or a wetland, and
   d. has a stable soil (not highly erodible or subject to landslides).
   e. will remain undisturbed so as to maintain the infiltration rate.

3. If the undisturbed area is between 10% and 15% slope, an additional 10% area is required for each percent of slope over 10%.

Examples of soil types recommended for natural infiltration areas (U) which are commonly found in Guilford County are shown in Table 2 below:

TABLE 2

| Soil Type | C In./In | d In. | f In./Hr. | Min. Ratio U/I | Max. Den. DU/A |
|---|---|---|---|---|---|
| Appling sandy loam | .25 | 6 | 1.02 | .5/1 | 9.7 |
| Cecil, Madison sandy loam | .25 | 4 | 1.02 | 1/1 | 7.2 |
| Enon, Vance, Helena Fine sandy loam and sandy loam | .17 | 4 | .27 | 2.8/1 | 3.8 |
| Cecil, Enon, Madison, Coronaca and Mecklenburg Sandy clay loam and clay loam | .14 | 4 | .17 | 8.3/1 | 1.4 |

Min. Ratio U/I = the minimum undisturbed area (acres) needed for infiltration of the first half inch of runoff per acre of impervious surface.

Example:

A development is proposed on a 20 acre site and the land use is medium density single family with a 25% impervious surface area. Assuming the site is located on an Appling sandy loam,

$$U = (.5)(20)(.25)/[(.25)(6)] - .5 = 2.5 \text{ acres undisturbed required on this 20 acre site.}$$

The undisturbed area (U), can also be obtained directly from Table 2 if the soil type is given. For this example;

$U/I = .5/1$

$U = (.5/1)\ (.25 \times 20) = 2.5$ acres undisturbed required

## WET DETENTION PONDS

Wet detention ponds shall be designed to meet the following minimum requirements:

STORAGE. A permanent water quality pool will be sized to provide a two week storage time. Because runoff is a function of land use (and its corresponding percent imperviousness), permanent pool storage volumes shall meet the requirements in Table 3.

DEPTH. The mean depth of the permanent pool for onsite wet detention basins shall range from 3-6 feet, and the mean depth for regional basins shall range from 3-10 feet.

LENGTH-WIDTH RATIO. In order to minimize short-circuiting, the length to width ratio shall be 2:1 or greater.

SIDE SLOPES ALONG SHORELINE. Side slopes shall be 4H:1V or flatter in order to reduce erosion potential, promote wetland vegetation, minimize safety hazards, improve aesthetics and facilitate maintenance activities.

LARGE DAMS. Dams over 15 feet high and over 10 acre-feet of impoundment capacity, require a dam safety permit from the North Carolina Department of Environment, Health and Natural Resources. If a permit is required, the detention pond must meet the general requirements herein and those contained in the North Carolina Dam Safety Act.

SMALL DAMS. Those detention ponds not requiring a dam safety permit shall meet the general requirements herein and those contained in Practice Standard - 378, Pond, by the U.S. Conservation Service.

PRINCIPLE SPILLWAY.

CAPACITY. The principle spillway shall be designed for a 10-year, pre-development storm. POST-DEVELOPMENT RATE SHALL EQUAL PRE-DEVELOPMENT RATE.

SIZE. Design pipe flow must be secured before the emergency spillway operates. The minimum difference in elevation between the crest of the riser and the crest of the emergency spillway is 1 foot. The minimum diameter of the principal spillway conduit shall be 15 inches. The minimum cross-sectional area of the riser will be 1.5 times that of the conduit.

AESTHETICS. The vertical riser shall be designed with an adequate anti-vortex device to improve the flow of water and with a trash rack or hood to prevent floating debris from clogging the principle spillway.

ANTI-SEEP. Anti-seep collars shall be installed on all pipe conduits through earth dams and embankments.

DRAIN PIPE. All plans shall show provisions allowing for the emptying of the pond within 48 hours.

TABLE 3

DETENTION STORAGE REQUIREMENTS
FOR PERMANENT POOL OF WET DETENTION BASIN

| % Impervious | Storage Capacity * (inches) |
|---|---|
| 0-6% | NR |
| 7-12% | 0.7 |
| 13-25% | 0.8 |
| 26-35% | 0.9 |
| 36-50% | 1.0 |
| 51-70% | 1.2 |
| 71-90% | 1.3 |

* Storage capacity is in units of "inches per acre of drainage area"

BARREL/RISER ASSEMBLY. Anti-floatation calculations shall be submitted. The riser/barrel material shall be aluminum or concrete pipe, shall have gasketed joints and the barrel shall be pressure tested.

DAM/EMBANKMENT

FILL MATERIAL. The dam or embankment shall be constructed of material with sufficient strength to remain stable and with low permeability to prevent seepage of water through the embankment.

FOUNDATION CUTOFF TRENCH. In order to prevent undermining of the dam by seepage, a cutoff trench backfilled with clay shall be built into the foundation of the embankment if naturally impervious soil is not located at the dam site.

SETTLEMENT. The top width of the dam shall be based on the total height of the embankment. For heights of 10 feet or less, the minimum top width shall be 10 feet. For heights greater than 10 feet, the minimum top width shall be 12 feet.

SIDE SLOPES. Side slopes of earthen dams and embankments shall be designed for stability and maintenance requirements, and shall be 4H:1V or flatter.

EMERGENCY SPILLWAY

CAPACITY. An emergency spillway shall be designed for a 100-year storm.

FREEBOARD. A minimum of one foot of freeboard from the top of the pool elevation from the 100-year storm to the top of the dam shall be provided. The minimum difference in elevation between the invert of the emergency spillway and the settled top shall be 2 feet.

DISCHARGE. Spillways shall be constructed so as to prevent the discharge through the spillway from impinging on the dam or principle embankment structure.

SEDIMENT STORAGE

TEMPORARY. Storage shall be provided for 0.5 acre-inches of sediment per acre disturbed in the watershed during development.

PERMANENT. Storage shall be provided after the site is stabilized for one eighth acre-inch per acre of total watershed.

If the sediment accumulated during development is removed after the site is stabilized, this volume can be reallocated to permanent sediment storage, and to other required volumes if there is a residual. Sediment is to be removed whenever the sediment storage volume is filled.

GENERAL DESIGN CRITERIA
At inflow points to the pond, energy dissipators such as rip-rap shall be used to reduce the velocity of the flow. The outflow channel downstream of the pipe outfall shall be designed to protect against erosion and scour from high velocities and turbulence. Rip-rap shall be provided at the points of discharge as necessary.

A 20 foot minimum buffer strip around the wet detention basin shall be established with low maintenance grasses and shrubs.

Access shall be provided to the pond for maintenance. This right-of-way shall have a maximum slope of 15% and minimum width of 20 feet and be continuous around the wet pond. A maintenance plan shall be included with the design which shall include a plan for sediment removal and disposal.

## DRY DETENTION BASINS

A dry detention basin is an impoundment formed by constructing a dam or embankment or by a combination of excavation and an embankment with an outlet structure to detain surface runoff for periods of generally around 24 hours. Dry detention basins shall be designed to meet the following minimum requirements:

STORAGE. Detention volumes for a 24-hour detention time shall meet the requirements in Table 4.

PEAK FLOW CONTROL. Required storage shall be based on maintaining the pre-development peak discharge for the future development watershed conditions as a minimum.

LENGTH-WIDTH RATIO. The minimum length to width ratio shall be 3:1. Length is defined as the distance from the inflow point to the outflow point, and width is defined as the surface area divided by the length.

BASIN SLOPES. The side slopes of the basin shall be no greater than 4H:1V in order to reduce erosion potential, promote aesthetics, and facilitate maintenance activities. The floor of the basin shall have a minimum slope of 2%.

TRICKLE DITCH. When flow through the dry extended area of the basin is constant, a low flow channel shall be provided to carry the flow.

PRINCIPAL SPILLWAY.
CAPACITY. The principal spillway shall be designed for a 10-year

pre-development storm.

AESTHETICS. The vertical riser shall be designed with an adequate anti-vortex device to improve the flow of water and with a trash rack or hood to prevent floating debris from clogging the outlet structure.

ANTI-SEEP. Anti-seep collars shall be installed on all pipe conduits through earth dams and embankments.

BARREL/RISER ASSEMBLY. Anti-floatation calculations shall be submitted. The riser/barrel material shall be aluminum or

TABLE 4

DETENTION STORAGE REQUIREMENTS
FOR DRY DETENTION BASINS

| % Impervious | Storage Capacity * (inches) |
|---|---|
| 0-6% | NR |
| 7-12% | 0.1 |
| 13-25% | 0.2 |
| 26-35% | 0.3 |
| 36-50% | 0.4 |
| 51-70% | 0.5 |
| 71-90% | 0.8 |

* Storage capacity is in units of "inches per acre of drainage area"

concrete pipe, shall have gasketed joints and the barrel shall be pressure tested.

EMERGENCY SPILLWAY

CAPACITY. An emergency spillway shall be designed for a 100-year storm.

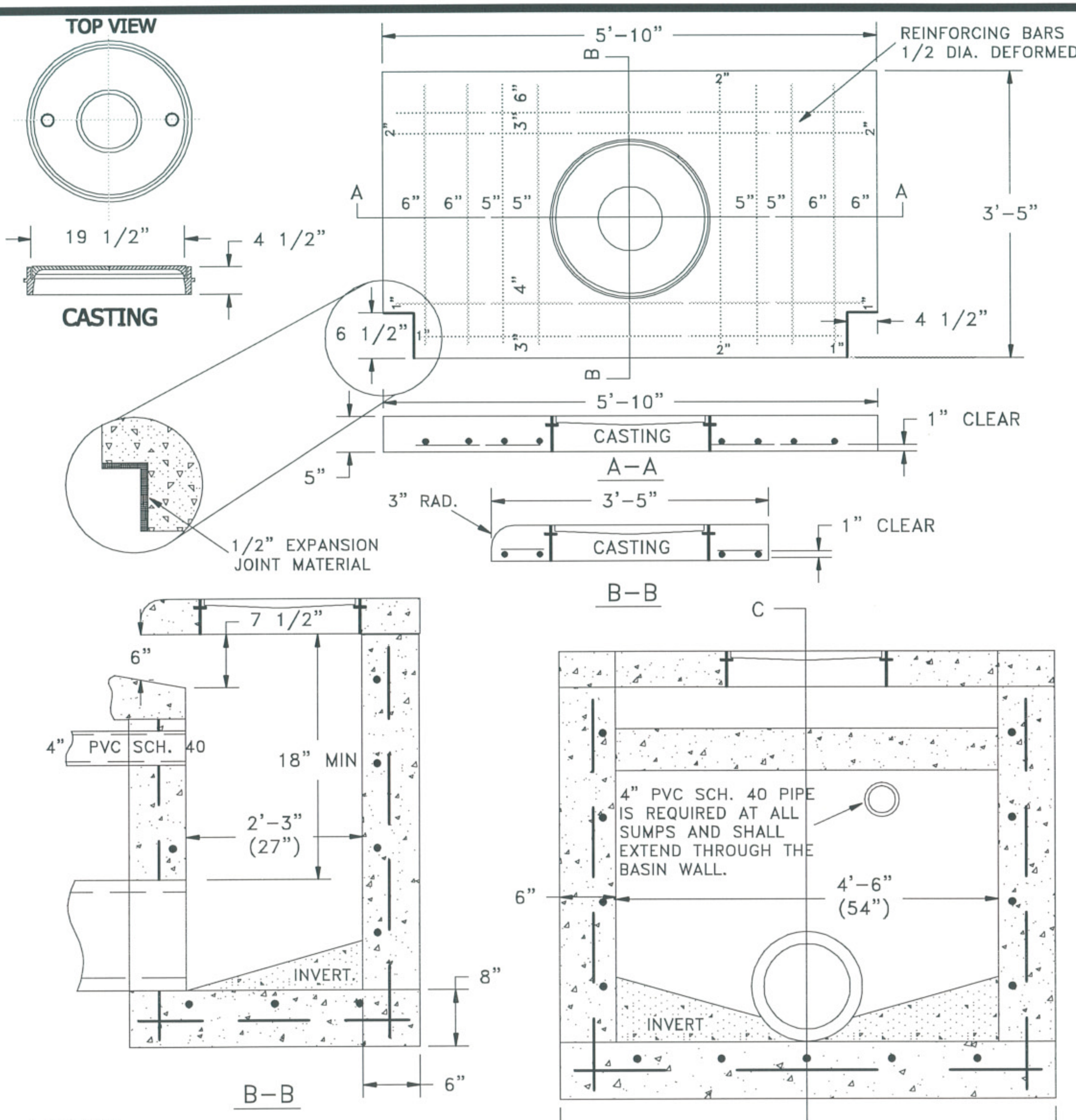
FREEBOARD. A minimum of one foot of freeboard from the top of the pool elevation from the 100-year storm to the top of the dam shall be provided.

GENERAL DESIGN CRITERIA

At inflow points to the pond, energy dissipators such as rip-rap shall be used to reduce the velocity of the flow. The outflow channel downstream of the pipe outfall shall be designed to protect against erosion and scour from high velocities and turbulence. Rip-rap shall be provided at the points of discharge as necessary.

A 20 foot minimum buffer strip around the dry detention basin shall be established with low maintenance grasses and shrubs.

Access shall be provided to the pond for maintenance. This right-of-way shall have a maximum slope of 15% and minimum width of 20 feet and be continuous around the site. A maintenance plan shall be included with the design and shall include a method for sediment removal and disposal.




# NOTES:

A. MANHOLE AND INLET MINIMUM WALL THICKNESS:

| DEPTH OF STRUCTURE | WALL THICKNESS |
|---|---|
| 0–12' | 6" |
| OVER 12' | 12" |

B. STEPS ARE REQUIRED IF DEPTH IS OVER 4'.

C. CONCRETE STRENGTH SHALL BE 3000 PSI MINIMUM.

D. REINFORCED STEEL CONFORMS TO LASTEST ACI–318 SPECIFICATIONS FOR REINFORCED CONCRETE. ALL REBAR IS #4 @ 12" O.C.E.W. WITH 1 1/2" COVER TYP. IN WALLS AND FLOOR.

E. CATCH BASIN SPECIFICATIONS CONFORM TO LATEST ASTM C–913 SPECIFICATIONS FOR "REINFORCED CONCRETE WATER AND WASTEWATER STRUCTURES".

F. REBAR TYPE B SPLICES SHALL BE USED.

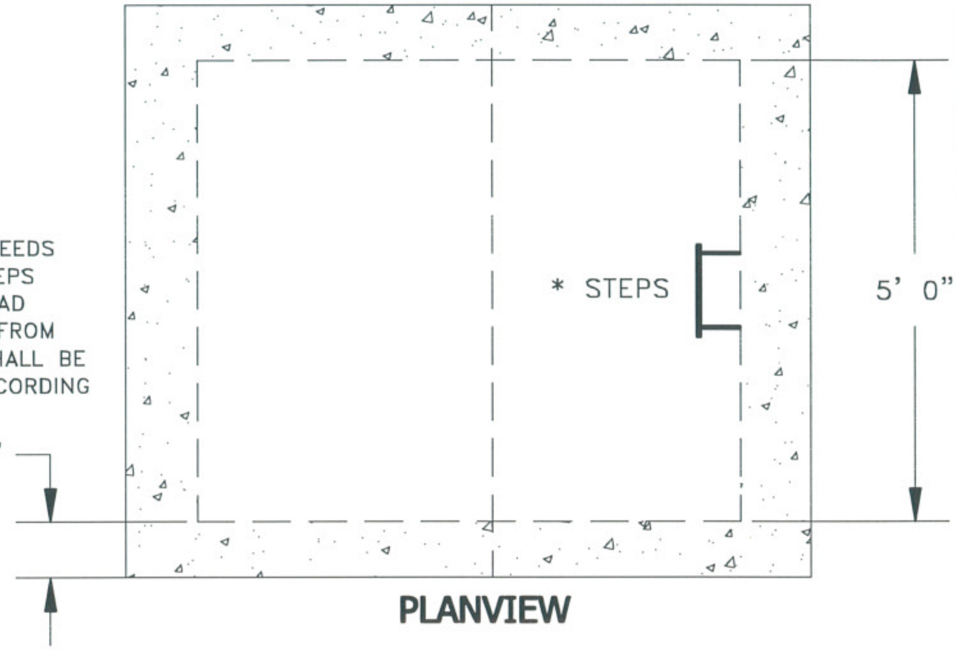
G. MANUFACTURED BY CAROLINA PRECAST CONCRETE, INC., OR OTHER APPROVED EQUAL.

**CITY OF HIGH POINT**
**NORTH CAROLINA**
**CENTRAL ENGINEERING**

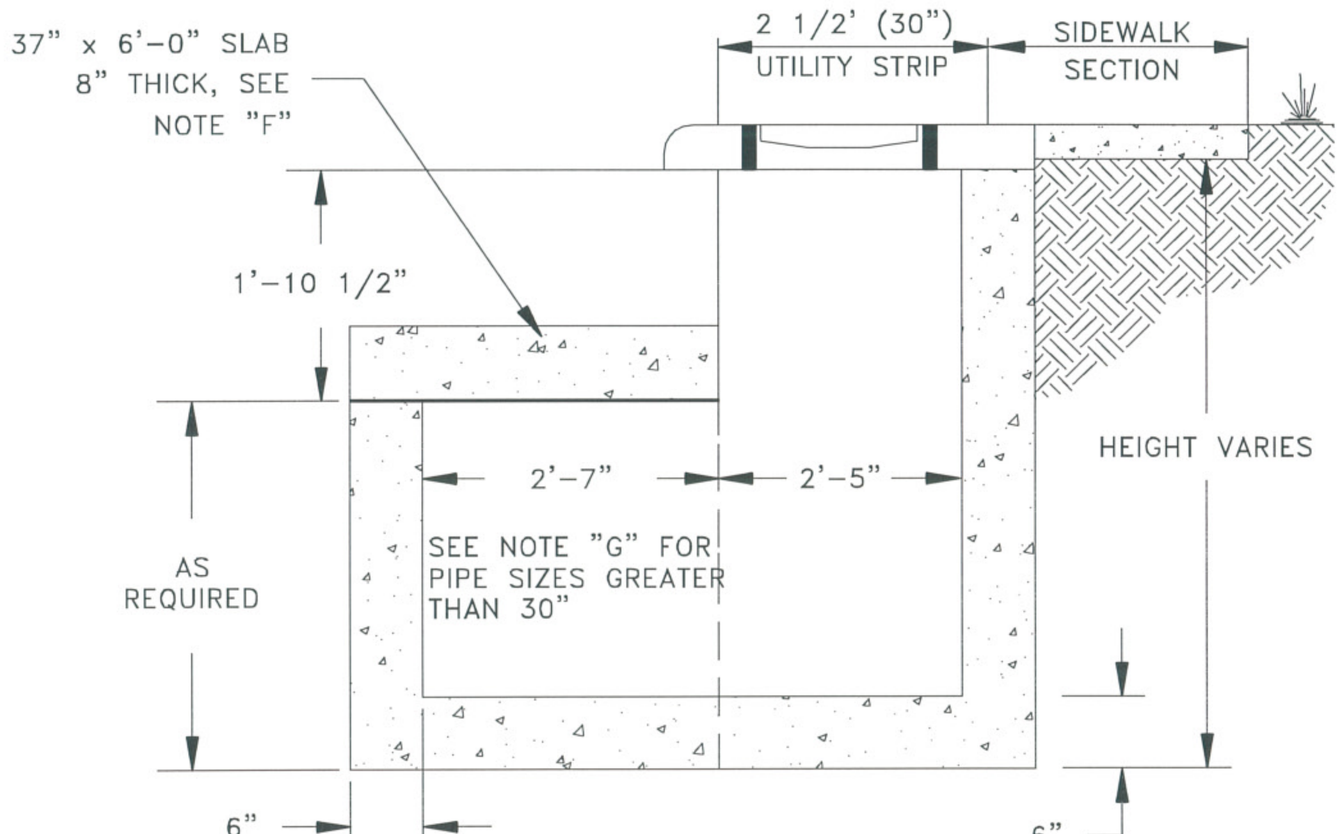
**STANDARD DETAIL DRAWING**
**REINFORCED PRECAST**
**CATCH BASIN TYPE "A"**

| DATE: NOV 96 | CBACAST.DWG | NO. 28.1 |
|---|---|---|

* STEPS ARE REQUIRED IF DEPTH EXCEEDS 4 FEET (4') OR AS DIRECTED. ALL STEPS INSTALLED SHALL HAVE SERRATED TREAD & TALL END LUGS TO PREVENT FEET FROM SLIPPING. STEP PULLOUT STRENGTH SHALL BE 2000 LBS. MINIMUM WHEN TESTED ACCORDING TO ASTM C497.




**PLANVIEW**




**SECTION VIEW**

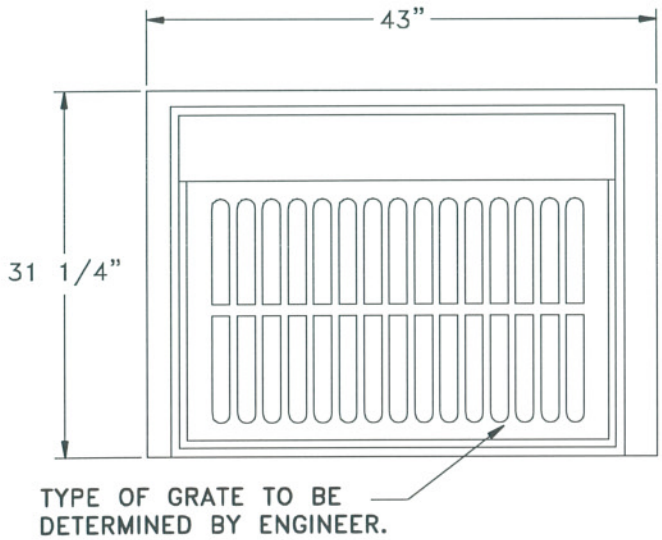
NOTES:

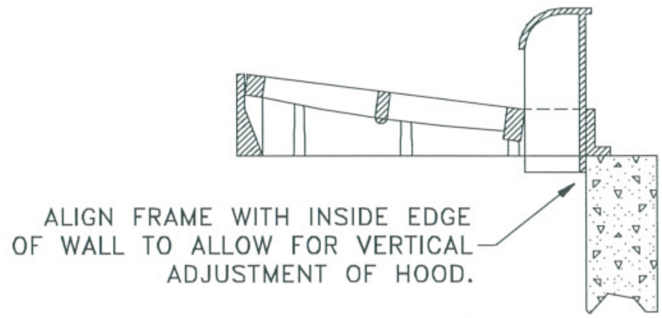
A. CATCH BASIN SPECIFICATIONS CONFORM TO LATEST ASTM C-913 SPECIFICATIONS FOR "REINFORCED CONCRETE WATER AND WASTEWATER STRUCTURES".
B. REFER TO CITY OF HIGH POINT STANDARD 28.0 FOR LID DIMENSION SPECIFICATIONS.
C. CONCRETE COMPRESSIVE STRENGTH IS 4000 PSI MINIMUM.
D. ALL REINFORCED STELL SHALL CONFORM TO ACI-318 SPECIFICATIONS FOR REINFORCED CONCRETE. ALL REBAR IS #4 @ 12" O.C.E.W. WITH 1" COVER TYPICAL IN WALLS AND FLOOR.
E. ONE POUR MONOLITHIC BASE SECTION.
F. SLAB SUPPORTS H-20 LOADING. #5 REBAR @ 12" O.C.E.W.
G. (2'-7") DIMENSION WILL INCREASE FOR PIPE WIDTHS GREATER THAN 30" RCP. AS THE PIPE SIZE INCREASES THIS DIMENSION WILL INCREASE PROPORTIONALLY.

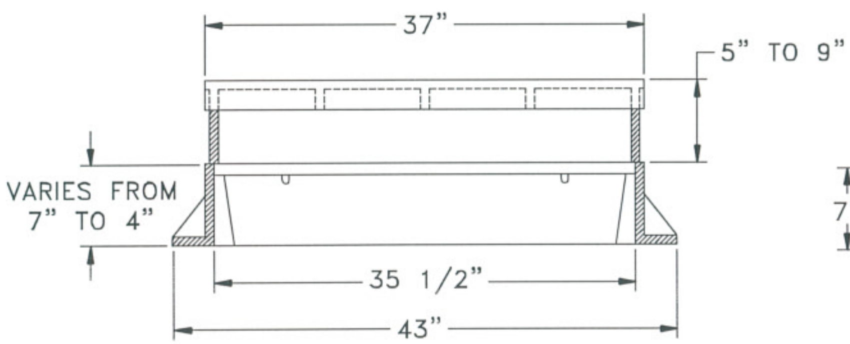
**CITY OF HIGH POINT**
**NORTH CAROLINA**
**CENTRAL ENGINEERING**

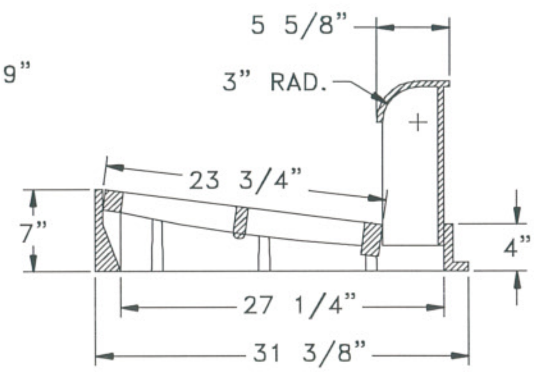
**STANDARD DETAIL DRAWING**
**SPECIAL TYPE "A"**
**CATCH BASIN**

| DATE: JULY 96 | CBA-S.DWG | NO. 28.2 |
|---|---|---|

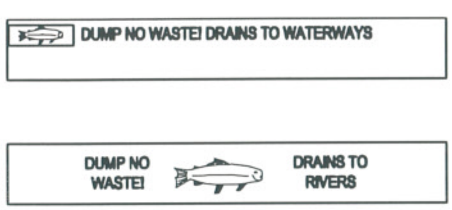



APPROVED HOOD DESIGNS:



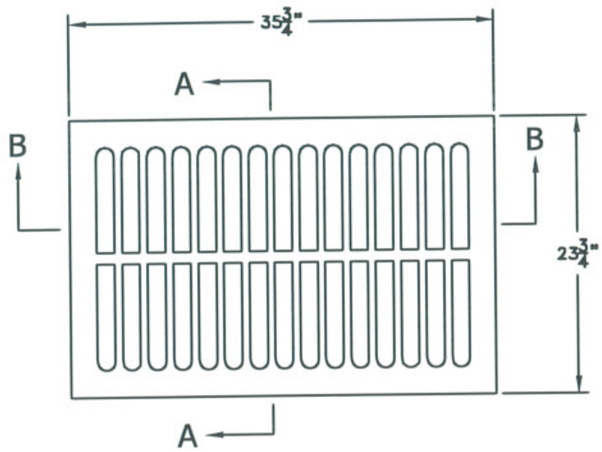

APPROVED MANUFACTURERS:
U.S. FOUNDRY HOOD (USF 5183-2 MODIFIED WITH FISH) AND FRAME (USF 5182), VULCAN FOUNDRY (EAST JORDAN IRON WORKS, INC.) HOOD AND FRAME (V-4066 WITH FISH LOGO) OR APPROVED EQUAL.

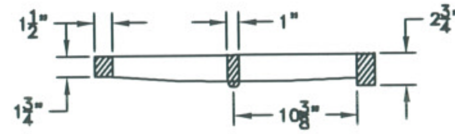
NOTES:

A. THE FRAME SHALL BE RATED HEAVY DUTY FOR HIGHWAY TRAFFIC LOADS (H-20 OR HS-20).

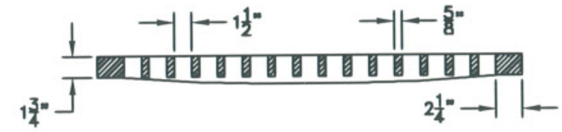
B. THE MATERIAL SHALL CONFORM TO THE LASTEST ASTM STANDARD SPECIFICATIONS FOR GRAY IRON CASTINGS (ASTM A48, CLASS 35).

| CITY OF HIGH POINT<br>NORTH CAROLINA<br>CENTRAL ENGINEERING | | |
|---|---|---|
| STANDARD DETAIL DRAWING<br>CURB AND GUTTER<br>FRAME, GRATE, AND HOOD INLET | | |
| DATE: MAR 00 | HOODGRAT.DWG | NO. 30.0<br>SHEET 1 OF 3 |




SECTION A-A

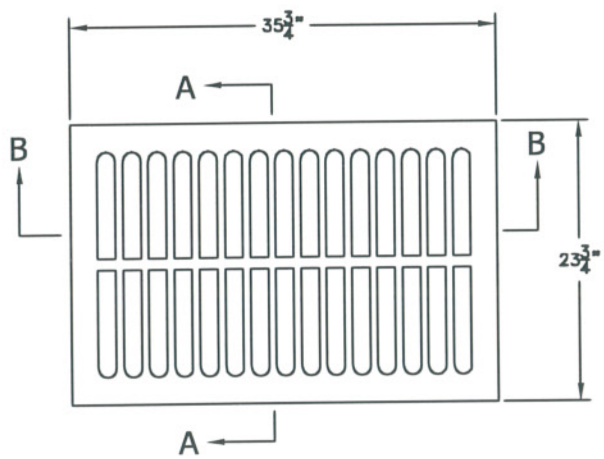


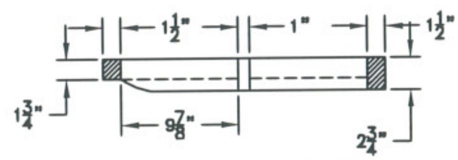

SECTION B-B

## TYPE "B" GRATE

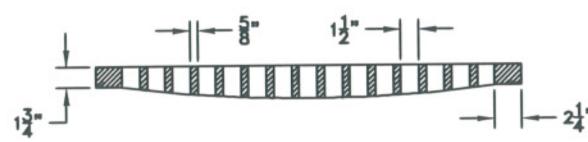
MINIMUM FLOW AREA: 381 SQ. IN.
MINIMUM GRATE WEIGHT: 185 LBS.

APPROVED MANUFACTURERS:
U.S. FOUNDRY (USF 5181-6428)
VULCAN FOUNDRY (V-4066-5)
OR APPROVED EQUAL.




SECTION A-A




SECTION B-B

## TYPE "E" GRATE

MINIMUM FLOW AREA: 430 SQ. IN.
MINIMUM GRATE WEIGHT: 190 LBS.

APPROVED MANUFACTURERS:
VULCAN FOUNDRY (V-4066-1 WITH FISH LOGO) OR U.S. FOUNDARY (USF 5181-6420) OR APPROVED EQUAL.

NOTES:

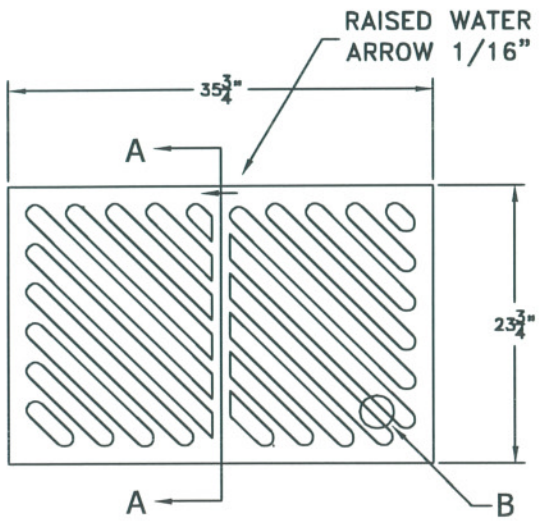
A. THE GRATE SHALL BE RATED HEAVY DUTY FOR HIGHWAY TRAFFIC LOADS (H-20 OR HS-20).

B. THE MATERIAL SHALL CONFORM TO THE LASTEST ASTM STANDARD SPECIFICATIONS FOR GRAY IRON CASTINGS (ASTM A48, CLASS 35).

**CITY OF HIGH POINT**
**NORTH CAROLINA**
**CENTRAL ENGINEERING**

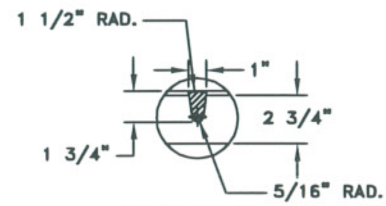
STANDARD DETAIL DRAWING
CURB AND GUTTER
FRAME, GRATE, AND HOOD INLET

| DATE: MAR 00 | HOODGRAT.DWG | NO. 30.1<br>SHEET 2 OF 3 |
|---|---|---|





SECTION A-A

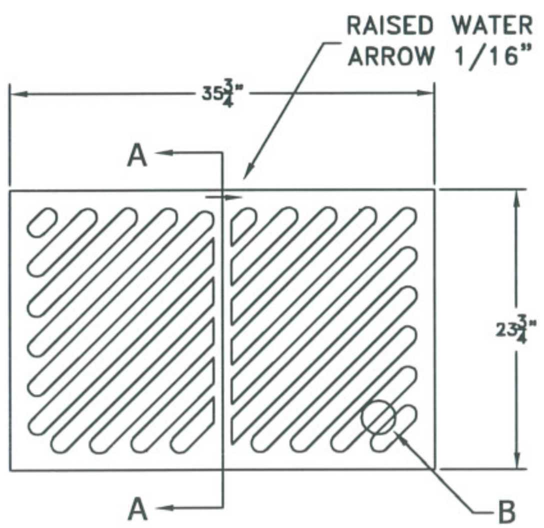



SECTION B

## TYPE "F" GRATE

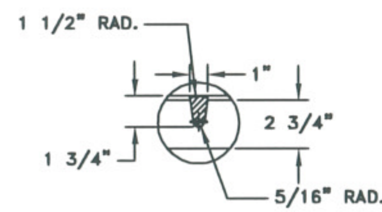
MINIMUM FLOW AREA: 369 SQ. IN.
MINIMUM GRATE WEIGHT: 200 LBS.

APPROVED MANUFACTURERS:
VULCAN FOUNDRY (V-4066-3)
OR APPROVED EQUAL.





SECTION A-A




SECTION B

## TYPE "G" GRATE

MINIMUM FLOW AREA: 369 SQ. IN.
MINIMUM GRATE WEIGHT: 200 LBS.

APPROVED MANUFACTURERS:
VULCAN FOUNDRY (V-4066-1 WITH FISH LOGO) OR U.S. FOUNDARY (USF 5181-6420) OR APPROVED EQUAL.

NOTES:

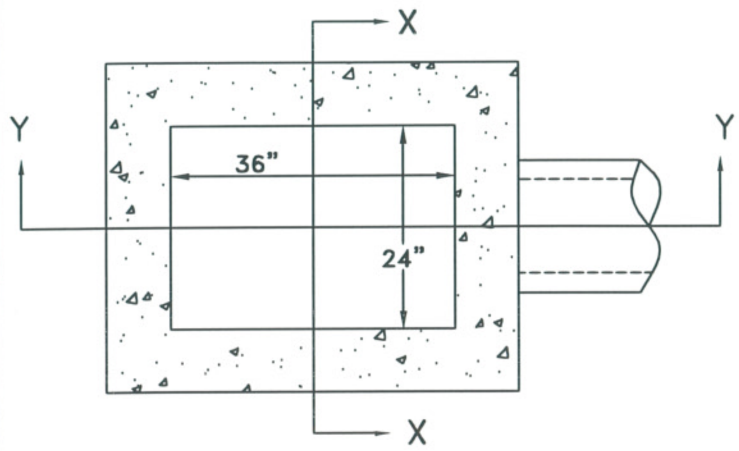
A. THE GRATE SHALL BE RATED HEAVY DUTY FOR HIGHWAY TRAFFIC LOADS (H-20 OR HS-20).

B. THE MATERIAL SHALL CONFORM TO THE LASTEST ASTM STANDARD SPECIFICATIONS FOR GRAY IRON CASTINGS (ASTM A48, CLASS 35).

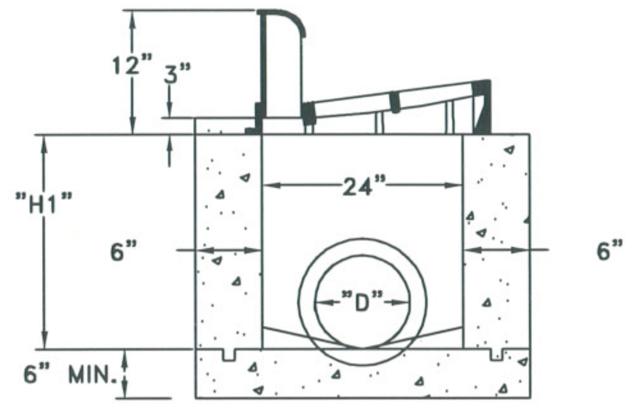
**CITY OF HIGH POINT**
**NORTH CAROLINA**
**CENTRAL ENGINEERING**

STANDARD DETAIL DRAWING
CURB AND GUTTER
FRAME, GRATE, AND HOOD INLET

| DATE: MAR 00 | HOODGRAT.DWG | NO. 30.2<br>SHEET 3 OF 3 |
|---|---|---|

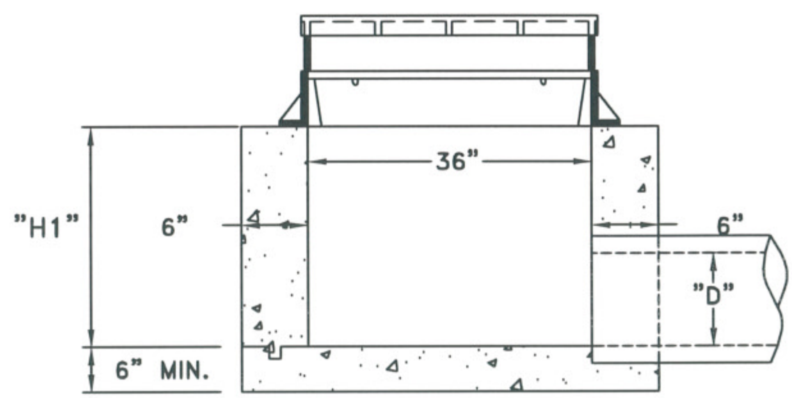



PLAN




SECTION X–X

| "D" PIPE DIAMETER | "H1" MINIMUM HEIGHT |
|---|---|
| 12" | 2' – 3" |
| 15" | 2' – 6" |
| 18" | 2' – 10" |
| 24" | 3' – 2" |




SECTION Y–Y

NOTES:

1. FOR 8' 0" IN HEIGHT OR LESS, USE 6" WALLS AND SLAB. OVER 8' 0" IN HEIGHT, USE 8" WALLS AND SLAB.
2. ALL CATCH BASINS OVER 3' 6" IN DEPTH ARE TO BE PROVIDED WITH STEPS 14" ON CENTER.
3. THE POURING OF FLOOR SLAB TO BE ACCOMPLISED BY FORMING.

| REV. | DESC. | BY |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**CITY OF HIGH POINT**
**NORTH CAROLINA**
**CENTRAL ENGINEERING**

STANDARD DETAIL DRAWING
PRECAST TYPE B CATCH BASIN
FOR 12" – 24" RCP

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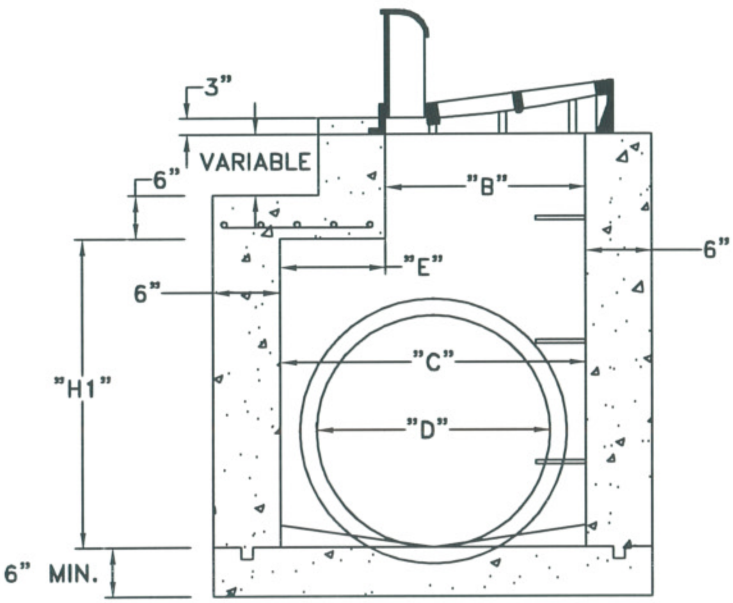
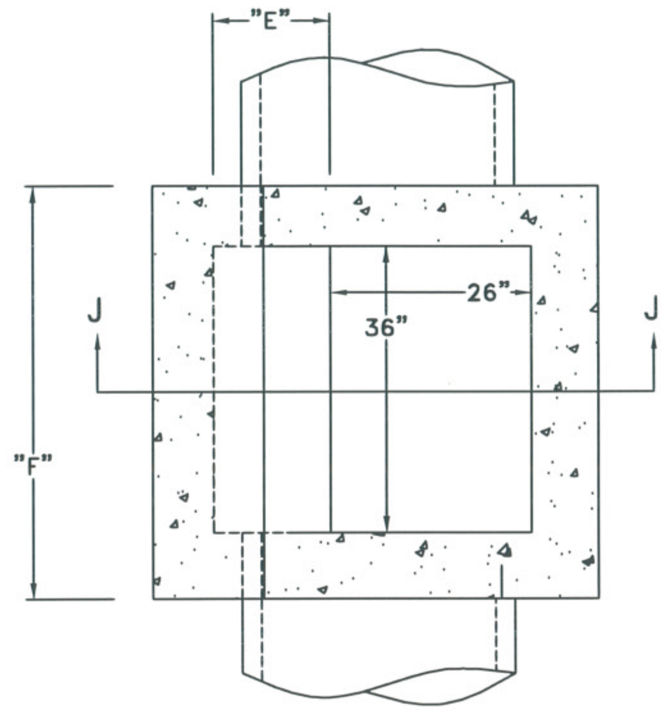
|---|---|---|---|




SECTION J–J




PLAN VIEW

| "D" PIPE DIAMETER | "H1" MINIMUM HEIGHT | "C" | "E" | "F" |
|---|---|---|---|---|
| 30" | 3' – 4" | 3' – 4" | 1' – 2" | 4' – 0" |
| 36" | 3' – 8" | 3' – 10" | 1' – 8" | 4' – 0" |

NOTES:

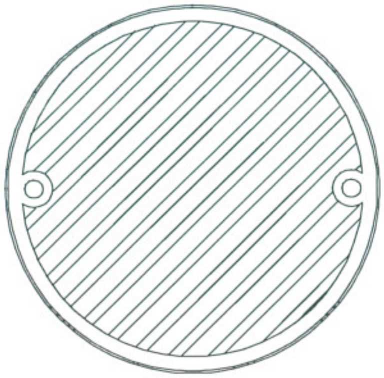
1. FOR 8' 0" IN HEIGHT OR LESS, USE 6" WALLS AND SLAB. OVER 8' 0" IN HEIGHT, USE 8" WALLS AND SLAB.
2. ALL CATCH BASINS OVER 3' 6" IN DEPTH ARE TO BE PROVIDED WITH STEPS 14" ON CENTER.
3. THE POURING OF FLOOR SLAB TO BE ACCOMPLISED BY FORMING.

| REV. | DESC. | BY |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**CITY OF HIGH POINT**
**NORTH CAROLINA**
**CENTRAL ENGINEERING**

STANDARD DETAIL DRAWING
PRECAST TYPE B CATCH BASIN
FOR 30" – 36" RCP

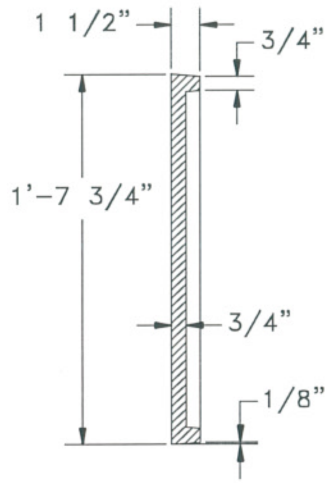
| .DWG | DATE: AUG. 01 | DWG. STD. 313.0 | PAGE 1 OF 1 |
|---|---|---|---|



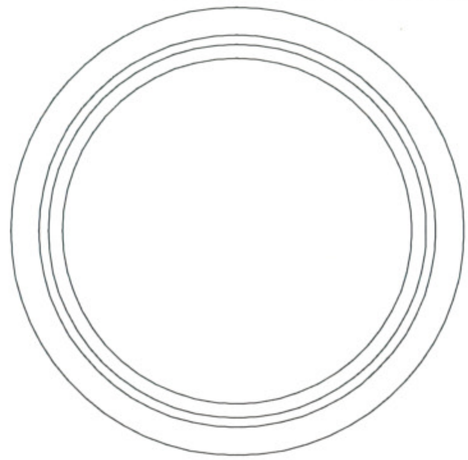
COVER BACK


OLD COVER FACE

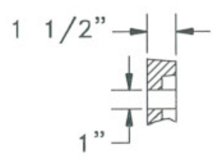

OR OPTIONAL "DRAINS TO RIVERS" ON COVER FACE



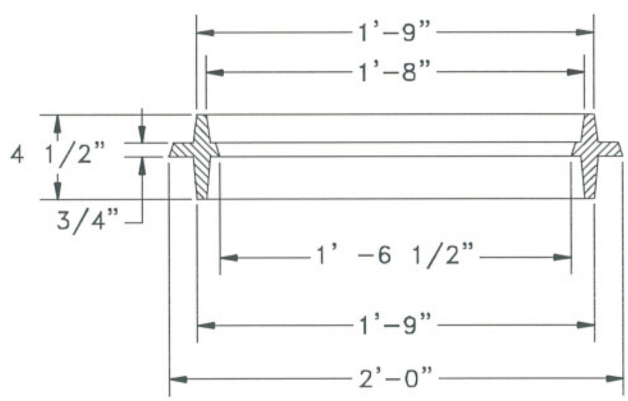

COVER SECTION



FRAME TOP VIEW




CORED HOLE DETAIL




FRAME SECTION

NOTES:

A. MINIMUM AVERAGE WEIGHT:

| | |
|---|---|
| COVER | 76 LBS. |
| FRAME | 61 LBS. |
| UNIT | 137 LBS. |

B. MATERIAL SHALL BE GRAY CAST IRON.

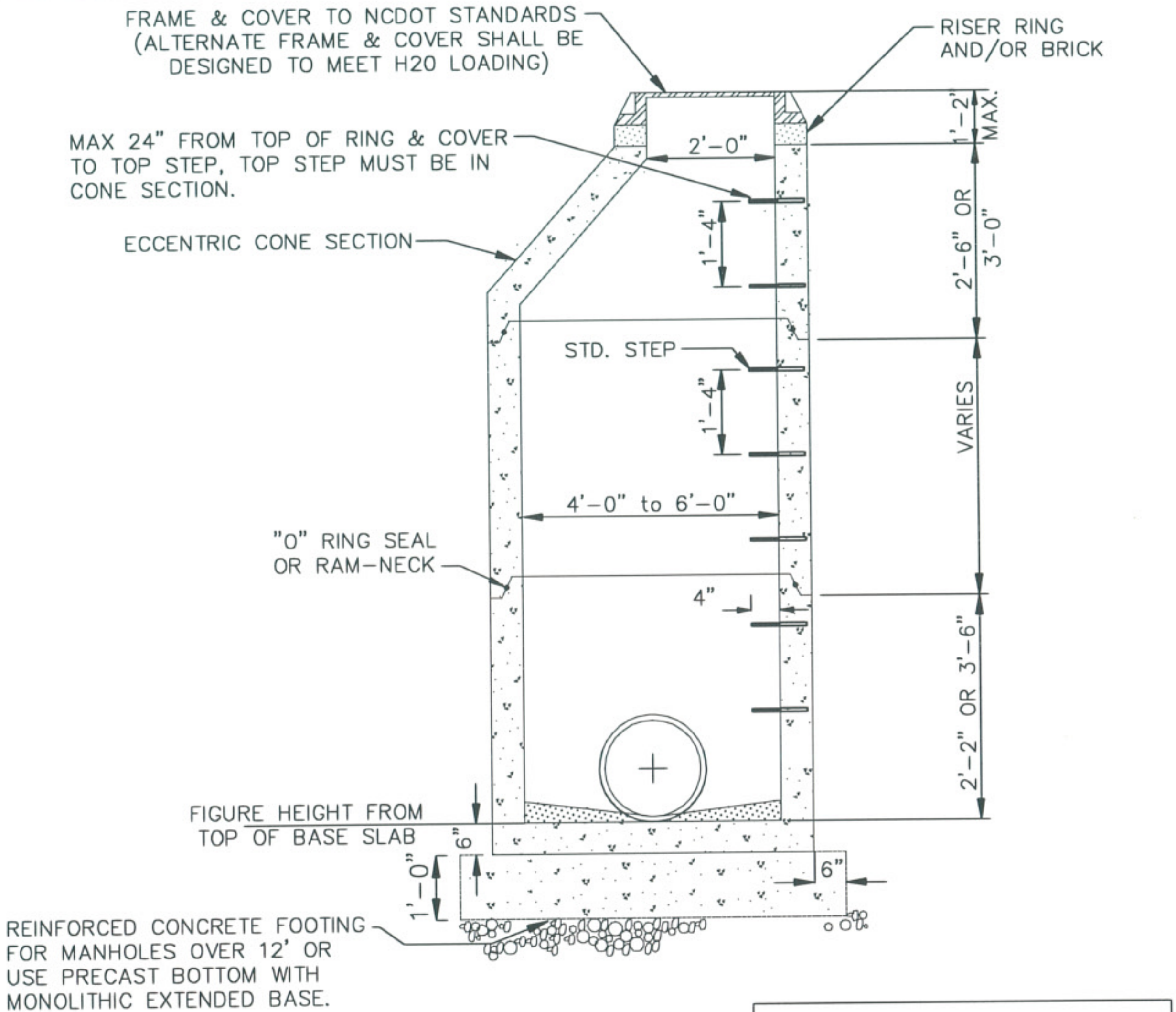
C. RING & COVER SHALL BE ASTM A-48 CLASS 35.

D. APPROVED MANUFACTURERS: VULCAN FOUNDARY INC. V-1887FI (WITH FISH), U.S. FOUNDRY USF 1162 LV RING AND FISH LOGO COVER, OR APPROVED EQUAL.

**CITY OF HIGH POINT**
**NORTH CAROLINA**
**CENTRAL ENGINEERING**

**STANDARD DETAIL DRAWING**
**FRAME AND COVER**
**FOR**
**TYPE "A" CATCH BASIN**

| DATE: APR. 99 | RC-BASIN.DWG | NO. |
|---|---|---|




TYPICAL MANHOLE DIMENSIONS
(unless otherwise noted on plans)
8" TO 12" RCP PIPE – 4'–0"
15" TO 30" RCP PIPE – 5'–0"
36" TO 54" RPC PIPE – 6'–0"

## GENERAL NOTES:

PRECAST MANHOLE COMPONENTS SHALL MEET REQUIREMENTS OF AASHTO M199.

RISERS & GRADE RINGS SHALL BE ASSEMBLED IN SUCH A MANNER AS TO CAUSE THE STEPS TO HAVE A SPACING OF 16" FROM TOP TO THE BOTTOM OF MANHOLE.

WHERE THE MANHOLE IS EXPOSED TO ROAD TRAFFIC, THE TOP OF THE MANHOLE IS TO BE FLUSH WITH THE GROUND AND AT OTHER LOCATIONS IT SHOULD BE A MINIMUM OF 3" ABOVE THE GROUND.

REINFORCED CONCRETE FOOTING REQUIRED WHEN MANHOLE IS OVER 12' AND ON POOR SOIL BASE. FOOTING AND BASE SECTION MAY BE PRECAST.

WHEN MANHOLE TOPS ARE IN EXCESS OF 3' ABOVE GRADE, OUTSIDE STEPS MUST BE PROVIDED.

MINIMUM 6" COMPACTED #67 STONE BASE TO BE INSTALLED UNDER NEW MANHOLE.

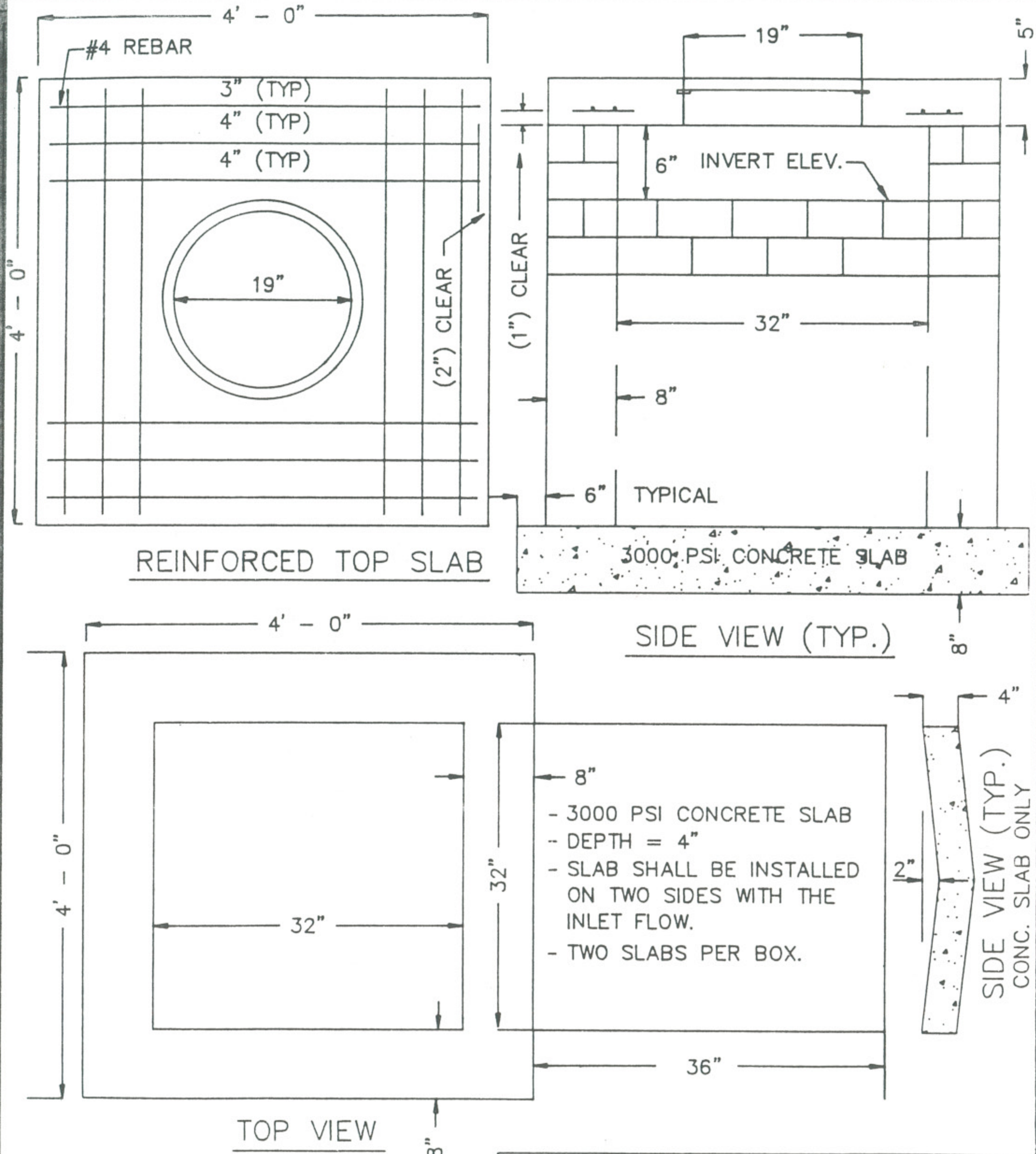
MANHOLE CONE AND BARREL SECTIONS SHALL BE AS PER N.C.D.O.T. STANDARD 840.53

NEW MANHOLES USE AN APPROVED BITUMINOUS BASE SEALANT THAT SHALL BE APPLIED TO THE TOP OF THE CONE SECTION TO PROVIDE A WATER TIGHT SEAL.

CITY OF HIGH POINT
NORTH CAROLINA
CENTRAL ENGINEERING

**STANDARD DETAIL DRAWING**
**STORM MANHOLE**

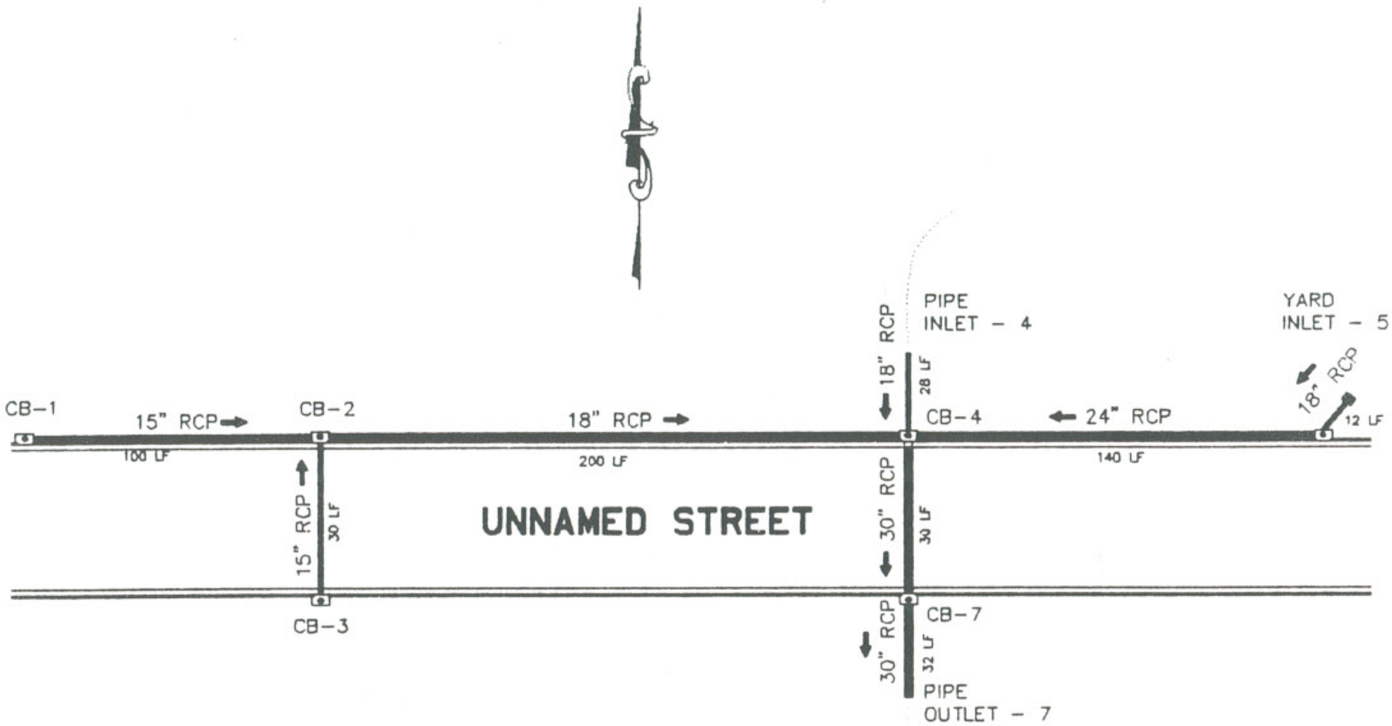
| DATE: MAY 96 | storm_mh.DWG | NO. |
|---|---|---|




NOTES:

1) STRUCTURE MAY BE BRICK OR CONCRETE.
2) REBAR TO BE USED IN THE LID TO BE #4 DEFORMED.

| | | |
|---|---|---|
| CITY OF HIGH POINT<br>NORTH CAROLINA<br>CENTRAL ENGINEERING | | |
| YARD INLET DETAIL | | |
| DATE: FEB. 91 | BY: JSD | NO. 74 |




**SAMPLE SCHEMATIC DRAINAGE PLAN**

CONSTRUCTION STORM DRAINAGE SCHEDULE

PROJECT:________________ FIRM:________________
LOCATION:________________ ENGINEER:__________ CHECKED:__________
ASSUMPTIONS:

CB -Catch Basin
FES - Flared End Section
GI - Grated Inlet
HW - Headwall
JB - Junction Box

MH - Manhole
PI - Pipe Inlet
PO - Pipe Outlet
YI - Yard Inlet

| STRUCTUR | | FROM STRUCTURE | | TO STRUCTURE | | PIPE | PIPE | SLOPE |
|---|---|---|---|---|---|---|---|---|
| FROM | TO | TOP | INVERT | TOP | INVERT | DIAMETER (INCHES) | LENGTH (FEET) | (%) |
| CB-1 | CB-2 | 890.00 | 886.00 | 888.20 | 883.50 | 15 | 100 | 2.50 |
| CB-3 | CB-2 | 888.20 | 884.00 | 888.20 | 883.50 | 15 | 30 | 1.67 |
| CB-2 | CB-4 | 888.20 | 883.00 | 886.00 | 881.10 | 18 | 200 | 0.95 |
| YI-5 | CB-6 | 891.00 | 886.00 | 888.00 | 883.50 | 18 | 72 | 3.47 |
| CB-6 | CB-4 | 888.00 | 883.00 | 886.00 | 880.40 | 24 | 140 | 1.86 |
| PI-4 | CB-4 | 886.00 | 881.20 | 886.00 | 880.90 | 18 | 28 | 1.07 |
| | | 886.00 | 881.20 | 886.00 | 880.90 | 18 | 28 | 1.07 |
| CB-4 | CB-7 | 886.00 | 879.90 | 886.00 | 879.60 | 30 | 30 | 1.00 |
| CB-7 | PO-7 | 886.00 | 879.40 | 880.50 | 879.10 | 30 | 32 | 0.94 |

ENGINEERING STORM DRAINAGE SCHEDULE

PROJECT:____________________ FIRM:________________________________
LOCATION:____________________ ENGINEER:__________ CHECKED:__________
ASSUMPTIONS:
INLET values are intercepted by the structure.
PIPE values are the accumulated values in the pipe.
Tc is based on City of High Point method.
10 Year design storm is being used.

| STRUCTUR FROM | TO | DRAINAGE BASINS INLET (ACRES) | PIPE (ACRES) | C | BASIN LENGTH (FEET) | Tc (MINUTES) | ____ YEAR INTENSITY (IN/HR) | FLOW INLET (CFS) | PIPE (CFS) | PIPE VELOCITY (FT/SEC) |
|---|---|---|---|---|---|---|---|---|---|---|
| CB-1 | CB-2 | 1.00 | 1.00 | 0.65 | 500 | 10.00 | 5.50 | 3.58 | 3.58 | 2.91 |
| CB-3 | CB-2 | 0.60 | 0.60 | 0.65 | 500 | 10.00 | 5.50 | 2.15 | 2.15 | 1.75 |
| CB-2 | CB-4 | 0.80 | 2.40 | 0.65 | 700 | 10.40 | 5.42 | 2.82 | 8.45 | 4.78 |
| YI-5 | CB-6 | 5.00 | 5.00 | 0.65 | 1,200 | 11.40 | 5.23 | 16.98 | 16.98 | 9.61 |
| CB-6 | CB-4 | 0.55 | 5.55 | 0.65 | 1,272 | 11.54 | 5.20 | 1.86 | 18.76 | 5.97 |
| PI-4 | CB-4 | 3.00 | 3.00 | 0.65 | 1,000 | 11.00 | 5.30 | 10.34 | 10.34 | 5.85 |
| | | 3.00 | 3.00 | 0.65 | 1,000 | 11.00 | 7.70 | 15.02 | 15.02 | 8.50 |
| CB-4 | CB-7 | 0.40 | 11.35 | 0.65 | 1,412 | 11.82 | 5.15 | 1.34 | 37.98 | 7.74 |
| CB-7 | PO-7 | 0.40 | 11.75 | 0.65 | 1,442 | 11.88 | 5.14 | 1.34 | 39.23 | 7.99 |

ENGINEERING STORM DRAINAGE SCHEDULE

PROJECT:____________________ FIRM:____________________
LOCATION:____________________ ENGINEER:__________ CHECKED:__________
ASSUMPTIONS:
Pipes are flowing full and n = 0.013 .
Headwater capacity basis:__________ Charts or Cd = 0.60
K values: Contraction - 0.25 | 60 degree - 0.55
Expansion - 0.35 | 30 degree - 0.28
90 degree - 0.70 | 15 degree - 0.10

| STRUCTUR FROM | TO | INLET STRUCTURE CAPACITY (CFS) | BYPASS (CFS) | HEADWATER DEPTH AVAILABLE (FEET) | REQUIRED (FEET) | MANNINGS (CFS) | PIPE FLOW BERNOULLI'S EQUATION Hf (FT) | TOTAL K | Hm (FT) | HYDRAULIC GRADE LINE OUTLET | INLET | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CB-1 | CB-2 | 2.0 | 1.58 | 4.00 | 0.99 | 10.21 | 0.31 | 0.60 | 0.08 | 886.06 | 886.99 | bypass to cb-2,cb-4 |
| CB-3 | CB-2 | 2.0 | 0.15 | 4.20 | 0.76 | 8.34 | 0.03 | 0.60 | 0.03 | 886.06 | 886.12 | bypass to cb-7 |
| CB-2 | CB-4 | 4.0 | -1.18 | 5.20 | 1.74 | 10.24 | 1.30 | 1.00 | 0.36 | 884.41 | 886.06 | |
| YI-5 | CB-6 | 22.0 | -5.02 | 5.00 | 4.73 | 19.57 | 1.89 | 0.60 | 0.86 | 885.93 | 890.73 | depth at yi < 1.0' |
| CB-6 | CB-4 | 2.0 | -0.14 | 5.00 | 2.54 | 30.82 | 0.96 | 1.00 | 0.55 | 884.41 | 885.93 | |
| PI-4 | CB-4 | 1,000.0 | -989.66 | 4.80 | 2.23 | 10.87 | 0.27 | 0.60 | 0.32 | 884.41 | 885.00 | max. wsel 885.4 |
| | | 1,000.0 | -984.99 | 4.80 | 3.86 | 10.87 | 0.57 | 0.60 | 0.67 | 886.60 | 887.85 | 100 yr wsel 886.8; road acts as a weir |
| CB-4 | CB-7 | 4.0 | -2.66 | 6.10 | 3.83 | 41.01 | 0.26 | 0.80 | 0.74 | 883.41 | 884.41 | |
| CB-7 | PO-7 | 4.0 | -2.66 | 6.60 | 4.01 | 39.71 | 0.29 | 0.60 | 0.60 | 881.00 | 883.41 | tw elev = 881.0 energy dissipator: 18'L x 10'W d50 = 6" |